SAUER DANFOSS

EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Technical Information

EHPS Steering Valve, PVE Actuation, OSPCX CN Steering Unit Technical Information

A Wide Range of Steering Components

Revision History

Table of Revisions

Date	Page	Changed	Rev
Mar 2009	35	Note added	BC
Oct 2009	Many	Steering column deleted	CA
Sep 2010	44	New back cover	CB

A Wide Range of Steering Components

F300 599

Sauer-Danfoss is the largest producer in the world of steering components for hydrostatic steering systems on off-road vehicles. Sauer-Danfoss offer steering solutions both at component and system levels. Our product range makes it possible to cover applications of all types - ranging from ordinary 2-wheel steering (also known as Ackermann steering) to articulated steering, complicated 4-wheel steering, automatic steering (e.g. by sensor) and remote controlled steering via satellite.
We can offer more than 1500 different steering units and 250 different priority valves categorized in types, variants and sizes.

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Front cover illustrations: F301 544, F301 545, P300 608, P300 619. Drawing: 150-04

A Wide Range of Steering Components

A Wide Range of Steering Components (continued)

For hydrostatic steering systems Sauer-Danfoss offers:

- Mini steering units with displacements from 32 to 100 cm^3/rev [1.95 to 6.10 in^3/rev], flow up to 20 l/min [5.28 US gal/min], steering pressure up to 125 bar [1813 psi].
- Steering units with displacements from 40 to 1200 cm^3/rev [2.44 to 73.2 in^3/rev], flow up to 100 l/min [26.4 US gaL/min, steering pressure up to 240 bar [3481 psi].
- Priority valves for rated flows at 40, 80, 120, 160 and 320 l/min [10.6, 21.1, 31.7, 42.3 and 84.5 US gal/min], pressure up to 350 bar [5076 psi].
- Pilot operated flow-amplifiers with amplification factors of 4, 5, 8, 10 or 20 for rated oil flows of 240 and 400 l/min [63.4 and 105.7 US gal/min], steering pressure up to 210 bar [3045 psi].
- Pilot operated steering valve with steering flow up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi] and with integrated priority valve for pump flow up to 120 l/min [31.7 US gal/min].

For electro hydraulic steering systems Sauer-Danfoss offers:

- Pilot operated steering valves (pilot operated by hydrostatic steering unit or by electrical signal) with steering flows up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi].
- Steering units with integrated electrical operated steering valve with steering flow up to 50 l/min [13.2 US gal/min], steering pressure up to 210 bar [3045 psi].
- Electrical operated steering valves with steering flow up to 40 l/min [10.57 US gal/min], steering pressure up to 210 bar [3045 psi].

Characteristic features for steering units:

- Low steering torque: From 0.5 Nm to 3 Nm in normal steering situations
- Low noise level
- Low pressure drop
- Many types available: Open center None reaction, Open center Reaction, Closed center None reaction, Load Sensing, Load Sensing Reaction
- One or more built-in valve functions: relief valve, shock valves, suction valves, none return valve in P-line and in LS-line
- Optional port connections (according to ISO, SAE or DIN standards)

Characteristic features for electrohydraulic steering system:

- Electrohydraulic steering valve EHPS: High steering pressure requiring smaller cylinders and flow
- EHPS: Low pilot pressure and flow giving extremely low noise in the cabin
- EHPS: The possibility of manual steering even on very heavy vehicles
- EHPS can be combined with Sauer-Danfoss PVG 32 proportional valve
- Minimization of side acceleration with articulated steering
- Posibility of GPS-, row sensor-, joy stick- steering and vaiable steering ratio

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Conversion Factors

1 N•m	=	[8.851 lbf•in]	1 cm^3	=	[0.061 in^3]
1 N	=	[0.2248 lbf]	1 l	=	[0.264 US gal]
1 bar	=	[14.50 psi]	°F	=	[1.8°C + 32]
1 mm	=	[0.0394 in]			

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EHPS Steering Valve, PVE Actuation, OSPCX CN Steering Unit Technical Information

Contents

Survey of Literature with Technical Data On Sauer-Danfoss Steering Components

Survey of Literature with Technical Data On Sauer-Danfoss Steering Components 6

General

General 7

Steering Valve EHPS and Electrical Actuation Module PVES for EHPS

Steering Valve EHPS and Electrical Actuation PVE for EHPS 8

Versions

Versions 8
- EHPS type 0, hydrostatic steering system: 8
- EHPS type 1, hydrostatic and electro-hydraulic steering system: 9
- EHPS type 2, hydrostatic and electro-hydraulic steering system: 10
- Functional Options overview 11
- EHPS type 0,1 or 2 with flanged on priority valve OLS 320: 12

Function

Function 13
- EHPS Valve 13
- PVES and PVED-CL, electrical actuation 16

Technical Data

Technical Data 17
- EHPS 17
- PVES 18
- PVED-CL 19
- Hysteresis, PVES and PVED-CL 19
- Technical Data PVES and PVED-CL 20

Installation

Installation PVED-CL 21

Variants

Variants 22

Dimensioning Steering System with EHPS Steering Valve

Dimensioning Steering System with EHPS Steering Valve 23

Technical Characteristics

Technical Characteristics 25

Dimensions

Dimensions 28
- EHPS Type 0, stand alone 28
- EHPS Type 1 and 2, stand alone 29
- EHPS Type 1 and 2, with PVG 30
- EHPS Type 1 and 2 with OLS 320 31

Hydraulic Systems

Hydraulic Systems 32
- EHPS type 0, stand alone and OSPCX CN steering unit 32
- EHPS type 1, stand alone, OSPCX CN steering unit and PVRES joystick 32
- EHPS type 1 with PVG 32, OSPCX CN pilot steering unit and PVRES joystick 33

Contents

System Safety
System Safety 34
Emergency steering 34
EHPS type 1 and type 2, prioritizing input signal 35
Fault monitoring 36
Safety Considerations 37

Order Specification
Order specification for EHPS and PVES 38

Steering Unit OSPCX CN
Steering Unit OSPCX CN 40

Version
Version 40

Code Numbers and Weights
Code Numbers and Weights 40

Specification Table for Non Catalogue Numbers of Sauer-Danfoss OSPCX CN Steering Units
Specification Table for Non Catalogue Numbers of Sauer-Danfoss OSPCX CN Steering Units 41

Technical Data
Technical Data 42

Dimensions
Dimensions 42

Notes
Notes 43

Contens and Technical Literature Survey

Survey of Literature with Technical Data on Sauer-Danfoss Steering Components

Detailed data on all Sauer-Danfoss steering components and accessories can be found in our steering component catalogues, which is divided in to 6 individual sub catalogues:

• General information	Steering components
• Technical data on mini steering units	OSPM
• Technical data on open center, and closed center steering units	OSPB, OSPC, and OSPD
• Technical data on load sensing steering units, priority valves and flow amplifiers	OSPB, OSPC, OSPF, OSPD, OSPQ, OSPL, OSPBX, OSPLX, OVPL, OLS and OSQ
• Technical data on hydraulic and electro-hydraulic pilot operated steering valves, electrical actuation modules and appropriate steering units.	EHPS, EHPS w. OLS 320, PVE for EHPS and OSPCX
• Technical data on combined steering unit/electro hydraulic steering valves and steering wheel sensors	OSPE and SASA

The most important data on all Sauer-Danfoss steering components is highlighted in a general survey brochure.
For technical information on individual variants, please contact the Sauer-Danfoss Sales Organization.

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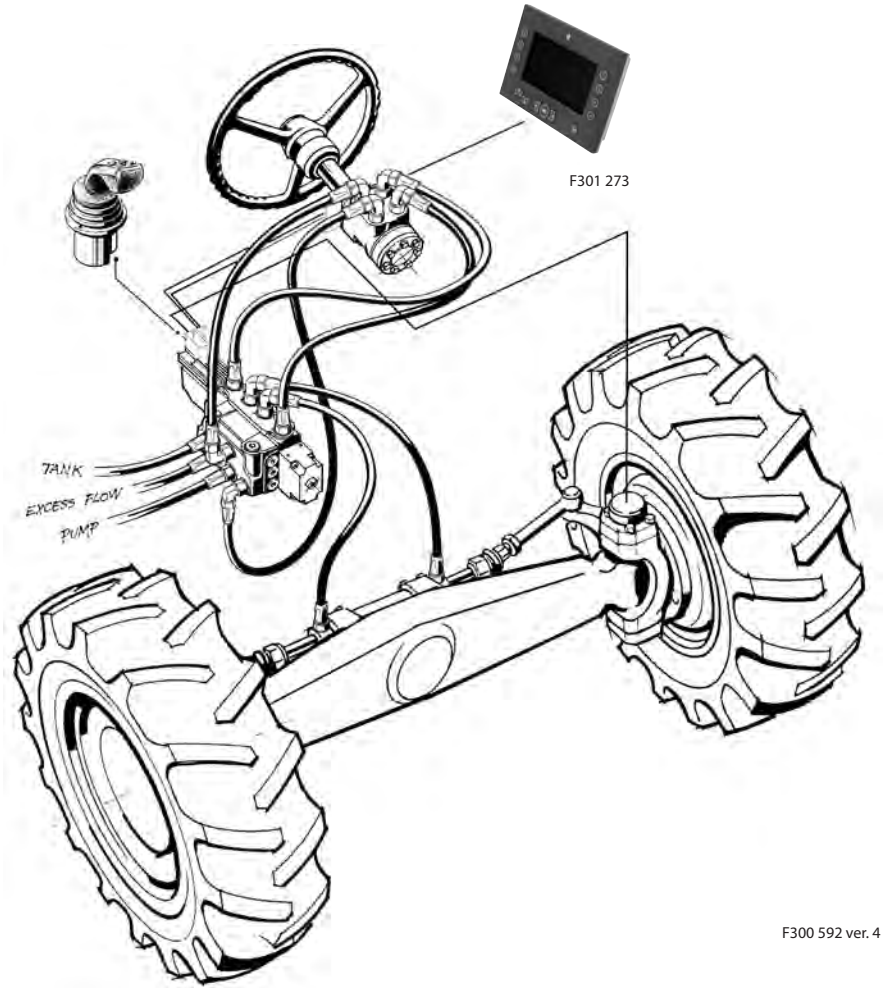
General

Electrohydraulic steering

On loaders, large forklift trucks, dumpers, heavy tractors, combine harvesters, maize harvesters and other similar machines there is often need for electrically actuated steering either in the form of a joystick, or fully automatic.
For this purpose Sauer-Danfoss has developed a pilot operated steering valve type EHPS (**E**lectro **H**ydraulic **P**ower **S**teering).
A basic system (type 0) consists of a pilot steering unit as the signal source and an EHPS valve block which controls oil flow to the steering cylinders proportional to the pilot flow.
The system can be extended to include an electrical actuator so that, as an alternative, it becomes possible to steer with a joystick (EHPS type 1).

Alternatively the actuator can be an electrical programmable module (PVED-CL) to give much more different steering features such like, variable steering ratio, speed dependent steering ratio, steering wheel drift compensation, active jerk force compensation and soft end stop. This system is called EHPS type 2.



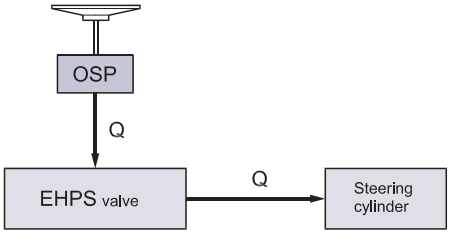
Electro hydraulic steering system

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Versions

EHPS type 0, hydrostatic steering system:

EHPS Type 0 is a hydraulic steering system only with the EHPS valve acting as a pilot operated directional valve. The steering unit type OSPCX CN acts as a pilot unit delivering oil at a low pressure and low flow. The steering unit needs less displacement compared with an ordinary hydrostatic steering system. The displacement can be optimized for emergency steering.



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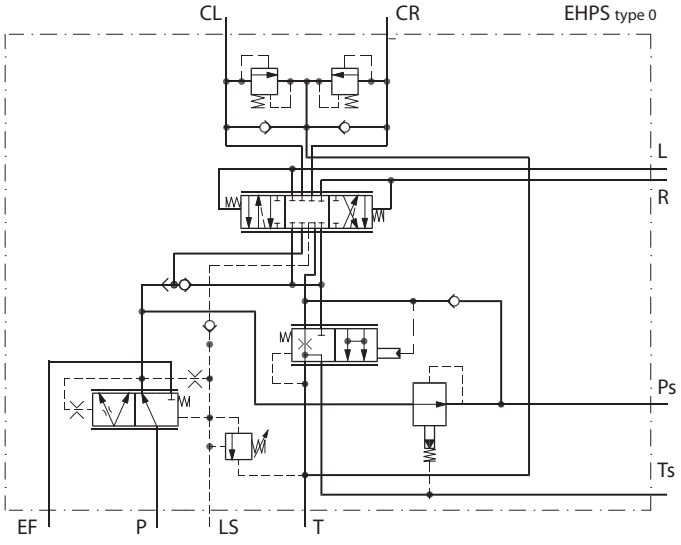

P301 028

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Versions

EHPS type 1, hydrostatic and electro-hydraulic steering system:
This system consists of an EHPS valve (type 0) equipped with an electrical module (PVES) for activating the EHPS valve. There are 2 possibilities of steering: either hydraulic with the steering wheel (OSPCX CN) or electrically using a signal from, for example, a joystick or a mini steering wheel. Input from the steering wheel (OSPCX CN) will always have highest priority.

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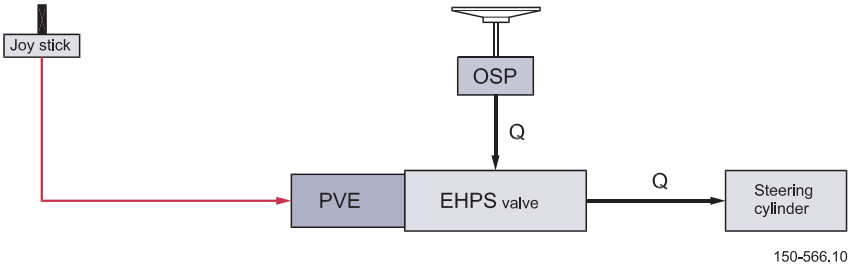

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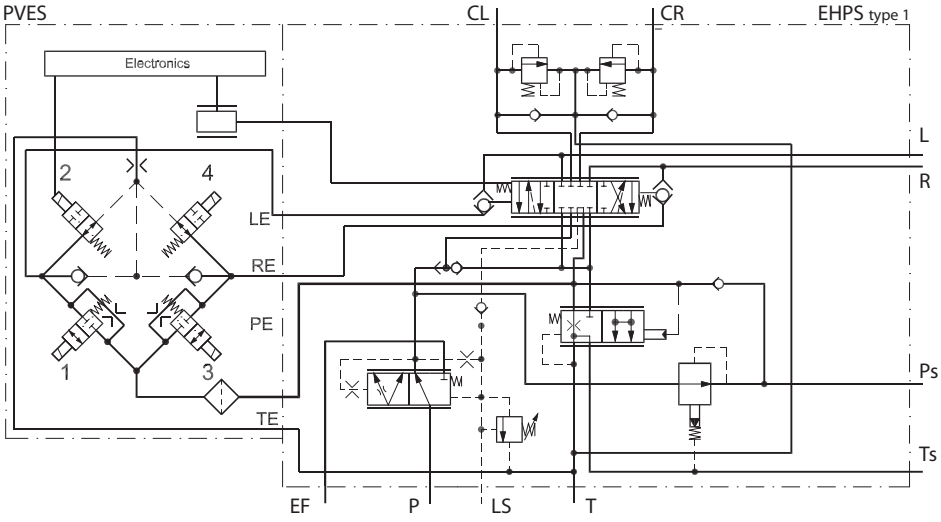

P301 026

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Versions

EHPS type 2, hydrostatic and electro-hydraulic steering system:

This system consists of an EHPS valve (type 0) equipped with an electrical programmable module (PVED-CL) for activating the EHPS valve. There are many possibilities of steering: With the steering wheel either pure hydraulic by help of the OSPCX CN steering unit or electro hydraulic by help of the SASA steering wheel sensor placed between column and steering unit.

The EPHS can be controlled electrically also by using signals from, for example, GPS controller, row censor, joy stick or mini steering wheel.

Input from the steering wheel will always have highest priority.

With PVED-CL the following steering features in electro hydraulic steer mode are possible:

- Variable steering ratio.
- Speed dependent steering ratio.
- Steering wheel drift compensation.
- Active jerk force compensation.
- Soft end stop

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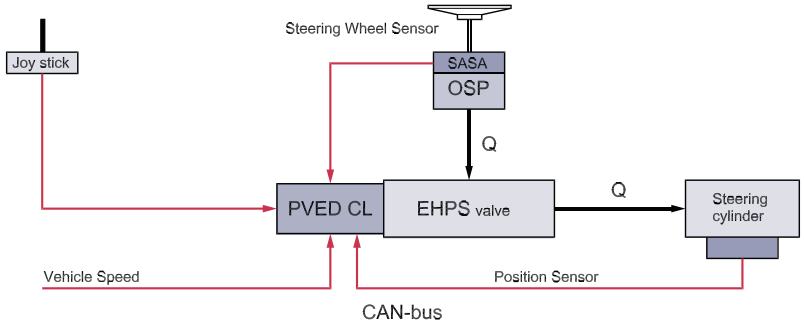

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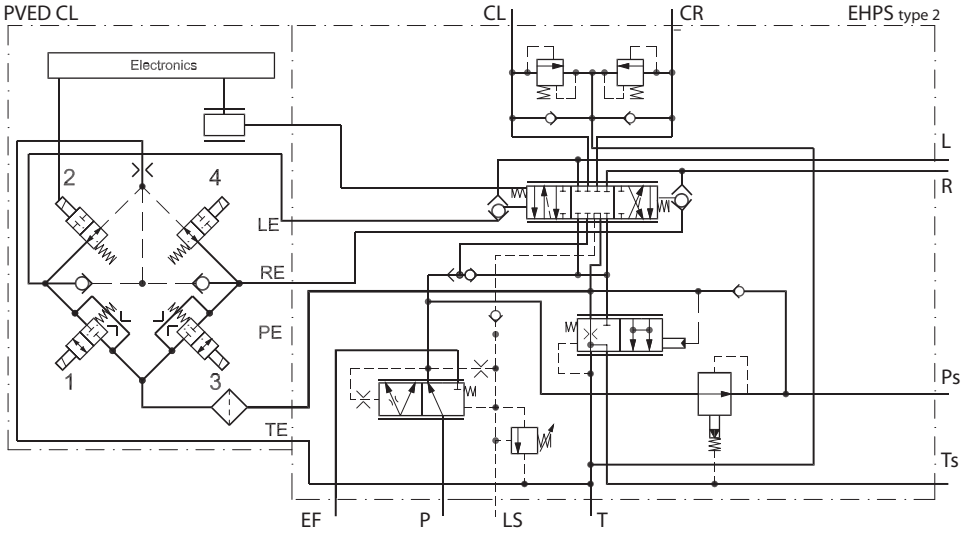
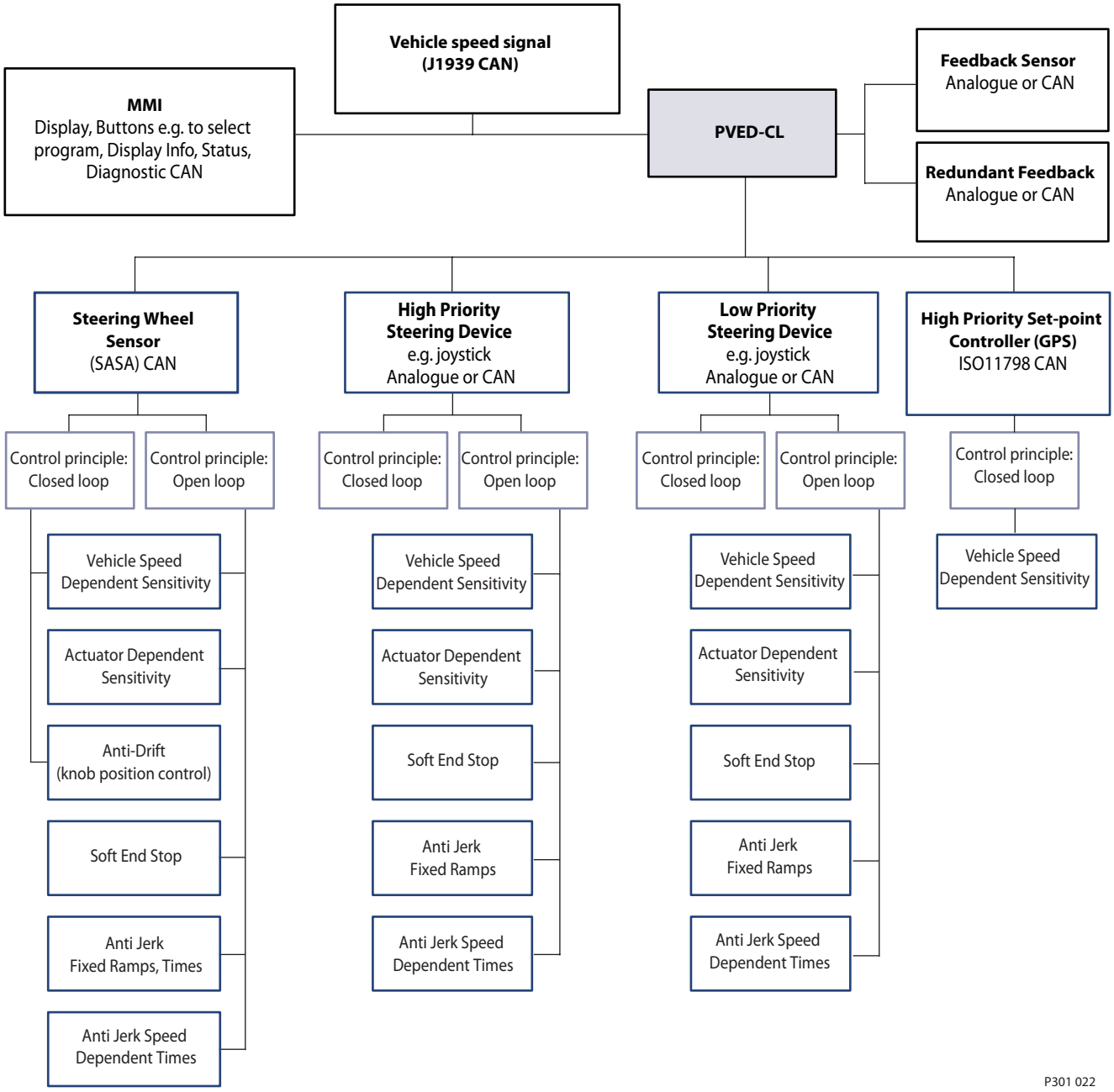


P301 027

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Functional Options overview

EHPS type 2, hydrostatic and electro-hydraulic steering system: (continued)
This block diagram shows all input devices possible for the PVED-CL actuator/controller. Detailed description is to be found in separate literature, PVED-CL User Manual, please contact Sauer-Danfoss Sales Organization.



Steering Valve EHPS and Electrical Actuation PVE for EHPS

Versions

EHPS type 0,1 or 2 with flanged on priority valve OLS 320:
EHPS sterring valve has build in priority valve, but for max. pump flow 120 l/min [31.7 US gal/min]. In systems with EHPS and pump flow between 120 l/min [31.7 US gal/min] and 320 l/min [84.5 US gal/min] a combination of EHPS and OLS 320 gives a good compact solution to reduce hosing and installation cost compared with stand alone components.

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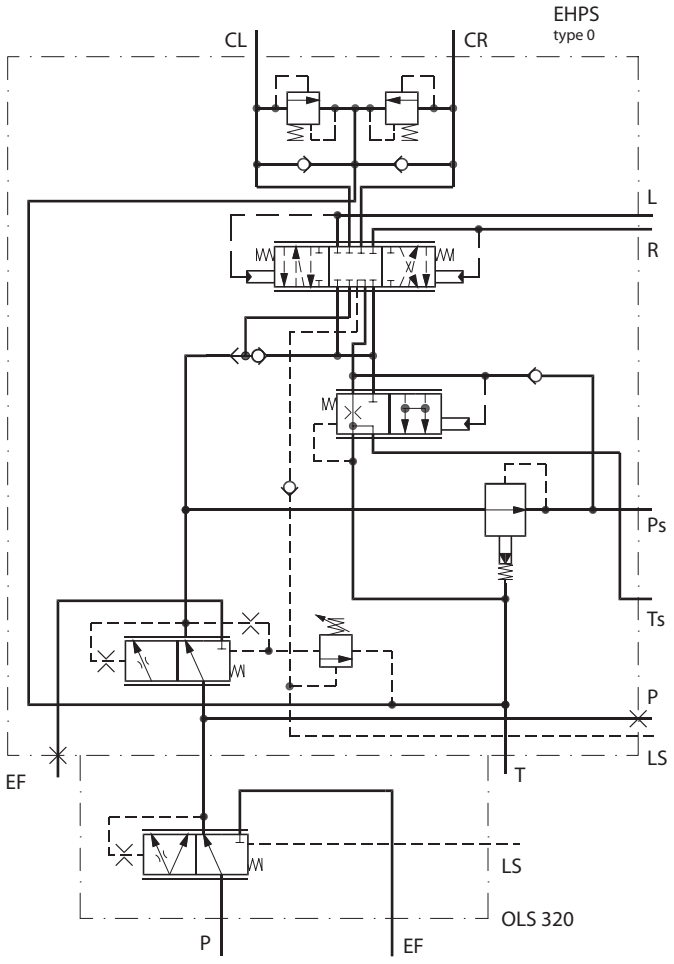

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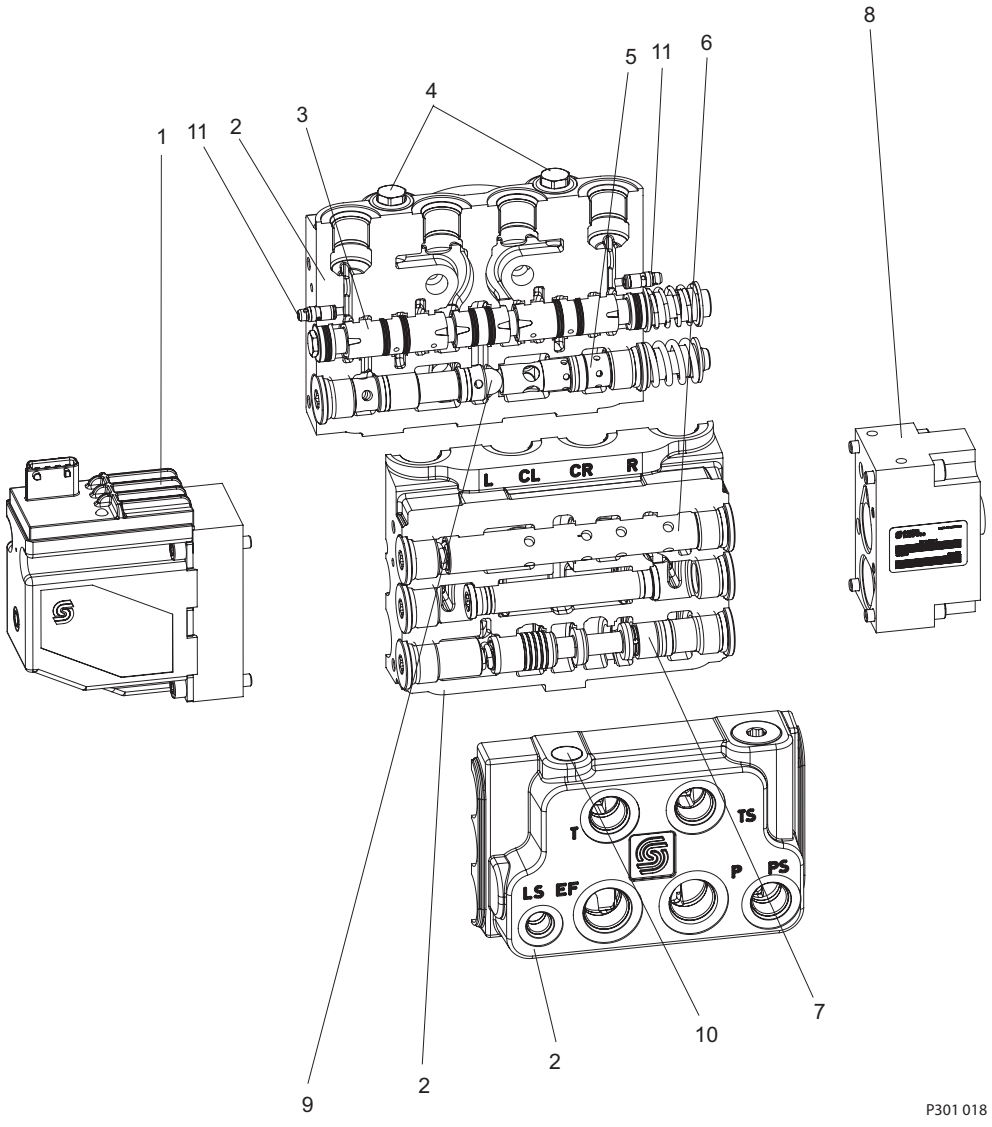
Steering Valve EHPS and Electrical Actuation PVE for EHPS

Function

EHPS Valve

The EHPS includes the following main components:



P301 018

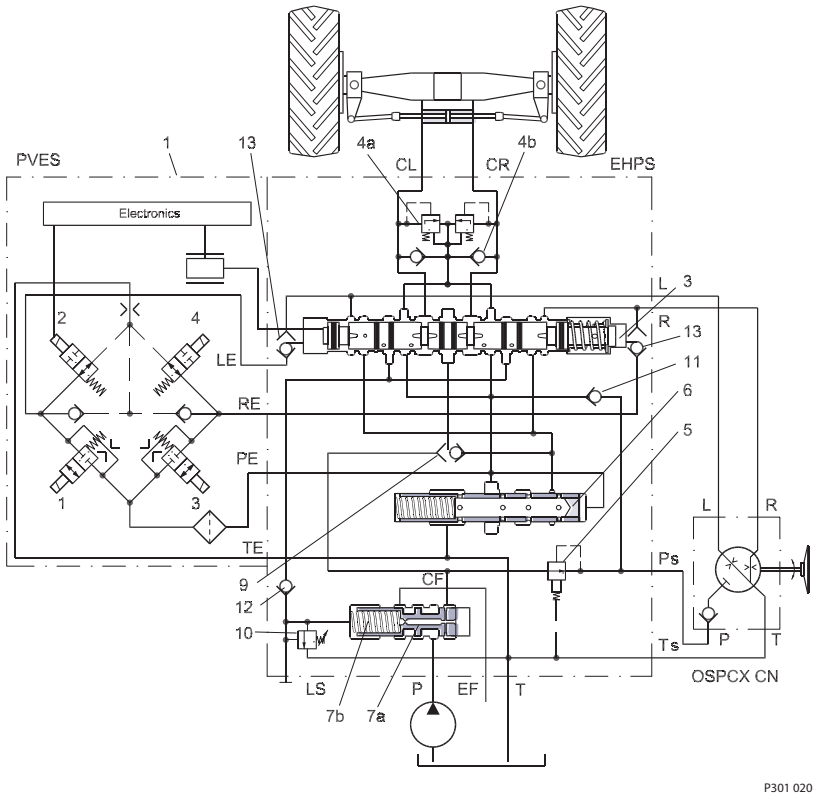
1. Electrical actuation module
2. Housing
3. Directional spool
4. Shock and suction valve
5. Pilot pressure reduction valve for steering unit
6. Pilot pressure valve for electrical actuating module also called metering valve
7. Priority valve
8. Cover
9. Emergency steering valve
10. Pilot pressure relief valve
11. Shuttle valves

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Function

1. Electrical actuation module
3. Directional spool
4a. Shock valves
4b. Suction valves
5. Pilot pressure reduction valve for steering unit
6. Metering valve
7a. Priority valve spool
7b. Priority valve spring
9. Emergency steering valve
10. Pilot pressure relief valve
11. Check valve for emergency steering
12 Check valve in LS line
13. Shuttle valves

Neutral position



When the engine is turned off, the priority valve spool (7a) is pushed to the right by the spring (7b).
The passage to the EF port is blocked and the passage to CF to the directional spool (3) is open.
When the engine is on and the steering unit OSPCX CN is in neutral position, the CF pressure will rise to match the spring force in the integrated priority valve, and the spool (7a) will move to the left and the oil will pass from the pump across the priority valve (7a + 7b) and out through the EF port.

The priority valve is a "dynamic" type, meaning that a flow passes from CF through the Dynamic orifice (integrated in spool 7a) and into the LS line through the check valve (12) to the directional spool (3). In neutral position this dynamic oil flow passes on to the tank.

When the steering unit is in neutral position and no signal is generated to PVES, the directional spool will be in its center position. This means that knocks and impacts from the cylinder are not transmitted to the steering unit.

Steering left

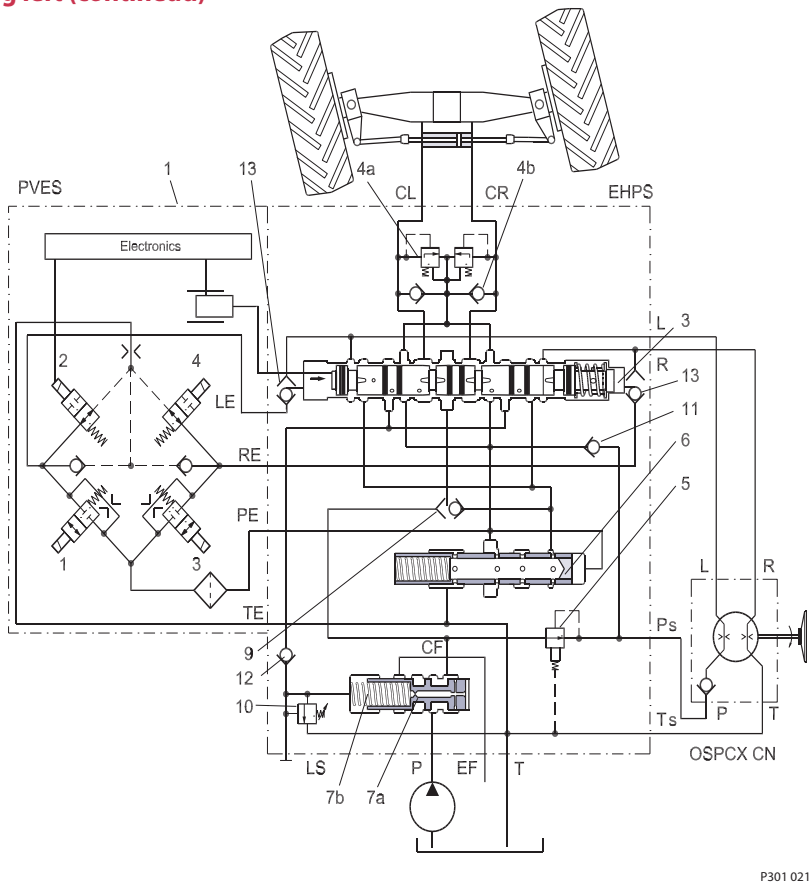
When steering, the steering unit will get oil supplied from the pilot pressure reduction valve (5).
The pressure for the steering unit is reduced to approximate 30 bar.
When steering left, oil will be passing on to the L-port of the EHPS and it will fill the left side chamber of the directional spool (3), which makes the spool move to the right.

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Function

1. Electrical actuation module
3. Directional spool
4a. Shock valves
4b. Suction valves
5. Pilot pressure reduction valve for steering unit
6. Metering valve
7a. Priority valve spool
7b. Priority valve spring
9. Emergency steering valve
10. Pilot pressure relief valve
11. Check valve for emergency steering
12. Check valve in LS line
13. Shuttle valves

Steering left (contineud)



When moving the directional spool (3), the LS signal will be connected to the steering pressure CL. The pressure will then increase in the spring chamber of the priority valve and the priority valve spool (7a) will be pushed towards the right side. Consequently, oil will flow through CF from the priority valve to the directional spool (3).
Oil will now push the steering cylinder rod out and it will cause steering to the left side. Return oil from the opposite cylinder site will stream into the CR port through the directional spool (3) and into the right end of the metering valve (6). The metering valve spool is moved to the left and the main stream from CR can pass through the metering valve into the tank.
The metering valve needs 12 bar to move. This return pressure is used for feeding an electrical actuation module PVES in a EHPS type 1 system.
When the metering valve is open, it also leads pilot oil from the steering unit to the tank. When the steering cylinder has reached end stop, no oil will pass through the CR port, and the control pressure for the metering valve (6) will be reduced. The metering valve will now move to the right, and the valve is closing the tank connection and the pilot oil flow will be blocked. This way you will feel the end stop in the steering wheel.

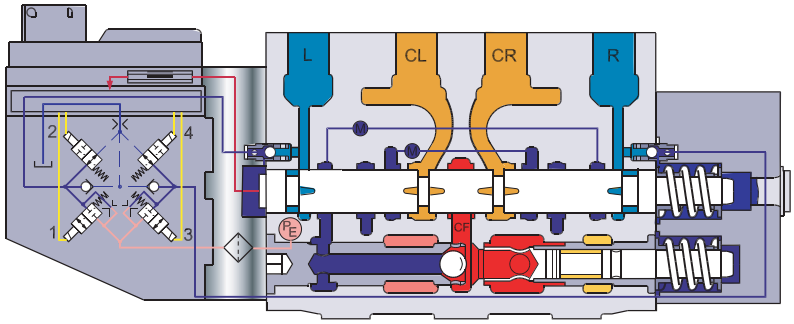
When turning right, the movement of the directional spool (3) will be opposite. All other functions are equal as when steering left. When steering with an electrical signal the directional spool (3) will be controlled by hydraulic signal from the PVES which is converting electrical signal to hydraulic signal to the directional spool (3), so that the movement of the directional spool (3) will be proportional to the electrical signal to the PVES. The shuttle valves (13) will lead oil from PVES (1) to directional spool (3).

Steering Valve EHPS and Electrical Actuation PVE for EHPS

Function

PVES and PVED-CL, electrical actuation

The philosophy of Sauer-Danfoss electro hydraulic actuation, type PVE, is integration of electronics, sensors and actuators into a single unit that interfaces directly to the EHPS steering valve body.



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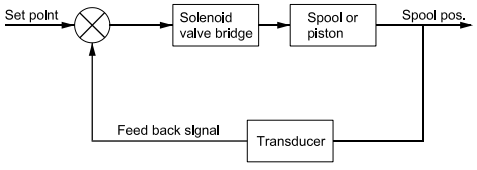
Closed loop control

All the proportional actuators feature an integrated feedback transducer that measures spool movement in relation to the input signal, and by means of a solenoid valve bridge, controls the direction, velocity and position of the directional spool of the valve. The integrated electronics compensate for flow forces on the spool, internal leakage, changes in oil viscosity, pilot pressure, etc. This results in lower hysteresis and better resolution. Furthermore the electronics enable built in safety like fault monitoring, directional indication and LED light indication.



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Principle

In principle the input signal (set-point signal) determines the level of pilot pressure which moves the main spool. The position of the directional spool is sensed in the LVDT transducer which generates an electric feed-back signal registered by the electronics. The variation between the set-point signal and feed-back signal actuates the solenoid valves. The solenoid valves are actuated so that hydraulic pilot pressure drives the directional spool into the correct position.

Inductive transducer, LVDT

(Linear Variable Differential Transformer). When the directional spool is moved, a voltage is induced proportional to the spool position. The use of LVDT gives contact-free monitoring of the directional spool position. This means an extra-long working life and no limitation as regards the type of hydraulic fluid used. In addition, LVDT gives a precise position signal of high resolution.

Integrated pulse width modulation

Positioning of the directional spool in PVES is based on the pulse width modulation principle. As soon as the directional spool reaches the required position, modulation stops and the spool is locked in position.

Technical Data EHPS

The technical data for EHPS are typical measured results. For the hydraulic system a mineral based hydraulic oil with a viscosity of 21 mm²/s [102 SUS] and a temperature of 50°C [122°F] was used.

EHPS "stand alone"

Max. pressure	Port P, EF, LS	250 bar	[3625 psi]
	Port CL/CR	320 bar	[4641 psi]
	Port L/R	125 bar	[1812 psi]
	Port Ps	55 bar	[798 psi]
	Port T, Ts	25 bar	[363 psi]
Oil flow rated	Port P, EF	120 l/min	[31.7 US gal/min]
	Port CL/CR/T	80/96 l/min [1) 2)]	[21/25 US gal/min]
	Port L/R/Ps	10/12.5 l/min [1) 2)]	[2.6/3.3 US gal/min]
Spool travel, directional spool		+/- 7mm	[+/- 0.27 in]
Dead band, directional spool		+/-1.5 mm	[+/- 0.06 in]
Priority valve	Spring force	10 bar	[145 psi]
	Nominal flow	120 l/min	[31.7 US gal/min]
Oil temperature	Recommended temperature	+30°C → + 60°C	[+86°F → +140°F]
	Min. temperature	- 30°C	[-22°F]
	Max. temperature	+ 90°C	[+194°F]
Ambient temperature		-30°C → + 60°C	[-22°F → +140°F]
Oil viscosity	Operating range	12 - 80 mm²/s	[65 - 370 SUS]
	Min. viscosity	10 mm2/s	[59 SUS]
	Max. viscosity	460 mm2/s	[2129 SUS]
Filtration[3)]	Max. contamination (ISO 4406, 1999 version)	21/19/16	

[1)] At 6 mm [0.24 in] spool travel with directional spool for maximum cylinder and pilot flow (80/10)
[2)] At 7 mm [0.28 in] spool travel (max travel) with directional spool for maximum cylinder and pilot flow (80/10)

Additional data's for EHPS with OLS 320

Priority valve, OLS 320	Spring force	10 bar	[145 psi]
	Nominal flow	320 l/min	[84.5 US gal/min]

Technical Data PVES

		PVES	
Supply voltage U_{DC}	rated	11 V to 32 V	
	range	11 V to 32 V	
	max. ripple	5%	
Current consumption at rated voltage	PVES	0.57 A @ 12 V	0.3 A @ 24 V
Signal voltage	neutral	0.5 x U_{DC}	
	CR-port ↔ CL-port	0.25 • U_{DC} to 0.75 • U_{DC}	
Signal current at rated voltage		0.25 mA to 0.70 mA	
Input impedance in relation to 0.5 • U_{DC}		12 KΩ	
Input capacitor		100 ηF	
Power consumption	PVES	7 W	

Reaction time

Supply voltage	Function		PVES Prop. super s
Disconnected by means of neutral switch	Reaction time from neutral position to max. spool travel	max.	0.230
		rated	0.150
		min.	0.120
Disconnected by means of neutral switch	Reaction time from max. spool travel to neutral position	max.	0.175
		rated	0.090
		min.	0.065
Constant voltage	Reaction time from neutral position to max. spool travel	max.	0.200
		rated	0.120
		min.	0.050
Constant voltage	Reaction time from max. spool travel to neutral position	max.	0.100
		rated	0.090
		min.	0.065

Technical Data PVED-CL

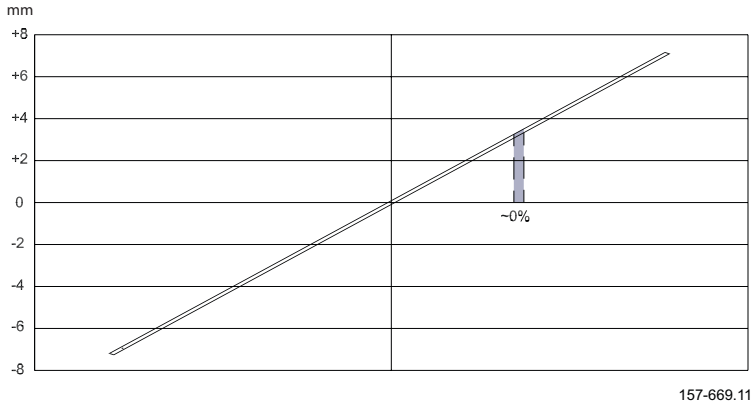
Electrical	Unit	Min	Max
Required supply voltage	V DC	11	32
Required current with magnetic valves enabled	A	1	0.3
Required current with magnetic valves disabled	A	0.1	0.03
Power consumption	W	7	10
Power consumption (magnetic valves off)	W	max 0.3	
Signals			
Stabilized voltage supply	V DC	4.80	5.20
Max current taken from stabilized voltage supply	mA	100	
Digital conversion of signals at AD1 & 2	V DC	0 to 5 VDC into 0 – 1023 (10 bit)	
Available baud rates to CAN	Kilo bit/s	125, 250, 500	
Performance			
Spool position Hysteresis in % of full spool stroke	-	0.5	1
Inherent Ramp-up time from neutral to full open	ms	50	210
Inherent Ramp-down time from full open to neutral	ms	40	150
Boot time EHPS software	ms	1200	1500
Recognition time of incorrect voltage signals	ms	50	
Recognition time of incorrect supply voltage	ms	200	
Recognition time of incorrect CAN signals	ms	200	
Recognition time of incorrect internal operations	ms	50 (watchdog)	

Hysteresis, PVES and PVED-CL

Hysteresis, PVES and PVED-CL[1)]	rated	~ 0%

[1)] Hysteresis is indicated at rated voltage and f = 0.02 Hz for one cycle (one cycle = neutral ->full CL -> full CR -> neutral.

Spool Travel



Technical Data PVES and PVED-CL

Oil consumption

Supply voltage	Function		PVES and PVED-CL
Without voltage	Pilot oil flow per PVE	neutral	0.3 l/min [0.078 US gal/min]
With voltage	Pilot oil flow per PVE	locked	0.1 l/min [0.026 US gal/min]
		continuous actuations	0.8 l/min [0.211 US gal/min]

Oil viscosity

Oil viscosity	range	12 - 75 mm²/s [65 - 347 SUS]
	min.	4 mm²/s [39 SUS]
	max.	460 mm²/s [2128 SUS]

Note: Max. start up viscosity 2500 mm²/s

Oil temperature

Oil-temperature	Rec. range	30 - 60°C [86 -140°F]
	min.	-30°C [-22°F]
	max.	90°C [194°F]

Filtering

Filtering in the hydraulic system	Max. allowed degree of contamination (ISO 4406, 1999 version): 23/19/16

Ambient temperature

Ambiant temperatur range Rec.	-30° → +60°C [-22° → +140°F]

Pilot pressure

Pilot pressure (relative to T pressure)	nom.	13.5 bar [196 psi]
	min.	10 bar [145 psi]
	max.	15 bar [217 psi]

Enclosure and connector

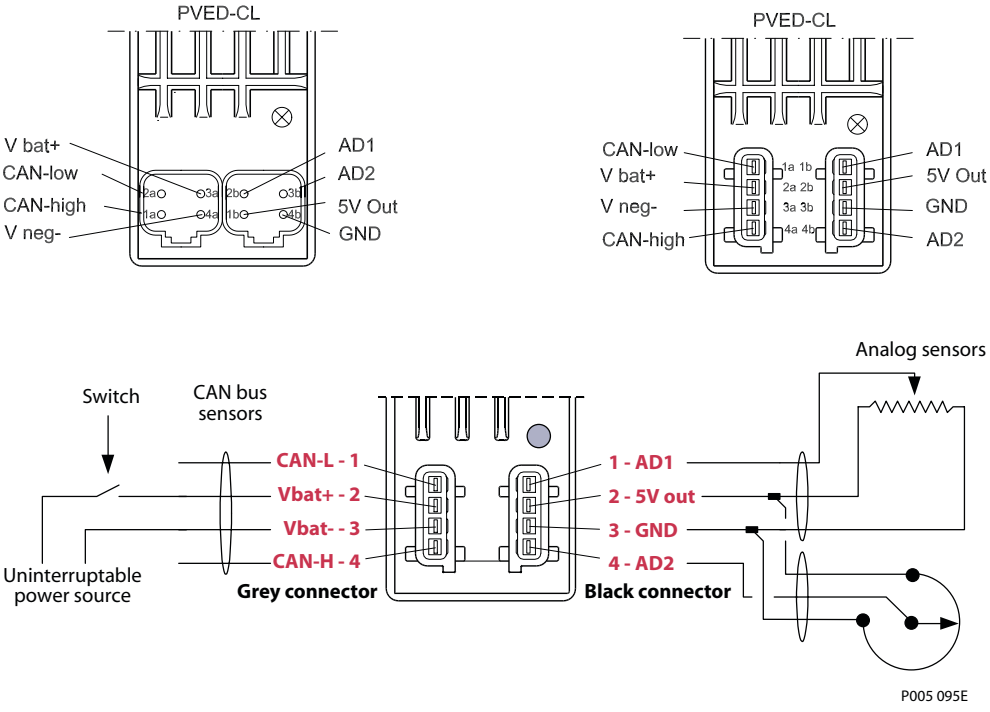
Version with AMP JPT connector	
Grade of enclosure *	IP 66

* According to the international standard IEC 529

In particulary exposed applications, protection in the form of screening is recommended.

Installation PVED-CL

The CAN-wiring is done according to J1939-15, where as Analogue wiring is recommended to be at least 0.75 mm^2 and no longer than 9 meters.



⚠ WARNING

The following wiring faults will destroy the PVED-CL '5V out' output:

- Connecting GND to 5V out AND Vbat+ to Vbat-
- Connecting Vbat+ to 5V out
- Short-circuit 5V out to GND for more than 5 minutes

Variants

In the table below is shown the available variants of the different modules in the EHPS valve.

Part	Variants															
Actuation module	Type 0 (none)								Type 1 (PVES) Connection AMP				Type 2 (PVED-CL) Connection AMP			
Directional spool [1]	Pilot flow (PQ) (l/min) [US gal/min] \ Cylinder flow (CQ) l/min [US gal/min]								20 [5.28]		40 [10.57]		60 [15.85]		80 [21.13]	
	5 [1.32]								CQ/PQ = 20/5		40/5		not available		not available	
	8 [2.11]								not available		40/8		60/8		80/8	
	10 [2.64]								not available		not available		60/10		CQ/PQ=80/10	
Housing [2]	Basic \ Thread								G			Metric			UNF	
	Stand alone								available			available			available	
	For PVG								available			available			available	
	For OLS 320 [3]								not available			available			available	
Relieve valve, bar [psi]	100 [1450]	110 [1595]	120 [1740]	130 [1885]	140 [2030]	150 [2175]	160 [2320]	170 [2465]	180 [2610]	190 [2755]	200 [2900]	210 [3045]	220 [3190]	230 [3335]	240 [3480]	250 [3626]
Shock valves, bar [psi]	160 [2320]	175 [2538]	190 [2755]		210 [3045]		230 [3335]		240 [3480]	250 [3626]	265 [3843]	280 [4061]		300 [4351]		320 [4641]

1) Directional spool:
Cylinder flow:
CQ = 20 l/min [5.28 US gal/min] is valid for 6 mm [0.24 in] spool travel.
CQ = 40 l/min [10.57 US gal/min] is valid for 6 mm [0.24 in] spool travel etc.
Pilot flow
PQ = 5 l/min [1.32 US gal/min] is based on steering unit with 50 cm^3/rev and 100 min^{-1} [rpm] and causes 6 mm [0.24 in] spool travel at 100 min^{-1} [rpm] steering wheel speed
PQ = 8 l/min [2.11 US gal/min] is based on steering unit with 80 cm^3/rev [4.88 in^3/rev] and 100 min^{-1} [rpm] etc.
For example if you need 60 l/min [15.85 US gal/min] cylinder flow at 100 min^{-1} [rpm] steering wheel speed and you need 80 cm^3/rev [4.88 in^3/rev] steering unit, you must choose directional spool 60/8.

2) Housing, threads:

	P & EF	Ps, Ts, T, CL, CR, L & R	LS
G, DIN 3852-2	G 3/4 - S**	G 1/2 - S**	G 1/4 - S**
Metric, ISO 6149-1	M 27 • 2 - O* + S**	M 18 • 1.5 - O* + S**	M 12 • 1.5 - O* + S**
UNF, ISO 11926-1	1 1/16 - 12 UN - O* + S**	3/4 - 16 UNF - O* + S**	7/16 - 20 UNF - O* + S**

3) OLS320 for EHPS, Housing, threads:

	P & EF	LS
SAE-ports	1 in SAE flange/M10 threads	None*** or M 12 • 1.5 - O* + S** or 7/16 -20 UNF - O* + S**
Metric, ISO 6149-1	M 33 • 2 - O* + S**	M 12 • 1.5 - O* + S**
UNF, ISO 11926-1	1 5/16 - 12 UN - O* + S**	7/16 - 20 UNF - O* + S**

O* : O-ring chamfer on port connection
S** : Spot face around port connection
None*** : If LS connection is going from OLS320 to LS connection of EHPS

Dimensioning Steering System with EHPS Steering Valve

The cylinder flow is determined from:
- Steering cylinder volume.
- Steering speed.

Dimension of steering cylinder(s) can be based on formulas in "General, steering components" page 29-31.

Symbols:

V (l)	steering cylinder volume
i (rev)	number of steering wheel revolutions from lock to lock
Vvc (cm3/rev.)	steering system displacement for steering cylinder
CQ (l/min)	nominal cylinder flow
Pems (bar)	emergency steering pressure
Tems (Nm)	emergency steering torque
Fe (N)	emergency steering wheel rim force
Swd (m)	steering wheel diameter
Vvs (cm3/rev)	displacement, steering unit
PQ (l/min)	pilot flow
Qpm (l/min)	pump flow, minimum

Example:
Cylinder volume: V = 1.85 l [0.49 US gal/min]
Required number of steering wheel revolutions from lock to lock:
i = 4 – 5 revolutions

The required steering system displacement for steering cylinder is calculated from
Vvc = V/i = (1.85*1000)/5 = 370 cm^3/rev [22.6 in^3]
(1.85*1000)/4 = 463 cm^3/rev [28.3 in^3]

In this example we chose Vvc = 400 cm3/rev
The directional spool is designated by nominal cylinder flow at 100 rpm speed on steering wheel.
CQ = 400 * 100/1000 (cm^3/l) = 40 l/min [10.6 US gal/min]

The pilot flow is mainly determined by the demand for emergency steering pressure, look in "General , steering components" page 28-29.

Emergency steering pressure, Pems, is calculated to be maximum
Pems = 40 bar [580 psi]

Maximum allowable steering torque Tems based on steering wheel rim force Fe = 350 N and steering wheel diameter Swd = 0.381 m [15 in]
Tems = Fe * Swd/2 = 350 * 0.381/2 = 66.7 Nm [590 lbf•in]

Pilot steering unit displacement can be chosen/calculated from the table lowest on page 28 in "General , steering components".
The nearest displacement Vvs generating minimum 40 bar [580 psi] at Tws = 66.7 Nm [590 lbf•in]
Vvs maximum = 80 cm^3/rev. [4.88 in^3]

As in an EHPS steering system pilot oil is dumped to the tank the steering unit displacement should be as small as possible.

Dimensioning Steering System with EHPS Steering Valve (continued)

In a given example you may be able to use a steering unit with smaller displacement as maximum size acceptable for emergency steering pressure.
This is determined by the required speed for steering the vehicle in a situation without pump oil supply.

In this example a 50 cm^3 [3.01 in^3] (Vvs chosen) steering unit could be big enough to obtain the required steering speed in emergency steering mode.
Pilot flow PQ is chosen by:
PQ = Vvs chosen * 100 rpm = 50 cm^3 [3.01 in^3]/rev * 100 rpm = 5 l/min. [1.3 US gal/min]

Designation CQ/PQ for directional spool is: 40/5.

Calculating pump flow:
If cylinder movement must correspond to steering wheel speed up to 100 rpm, the minimum pump flow Qpm for steering will be:

Qpm = CQ + PQ = 40 + 5 = 45 l/min [11.9 US gal/min]

If pump flow is insufficient, the steering cylinder speed will not match the steering wheel speed: the faster you steer, the higher pilot flow will be, and less flow will be left for cylinder movement.

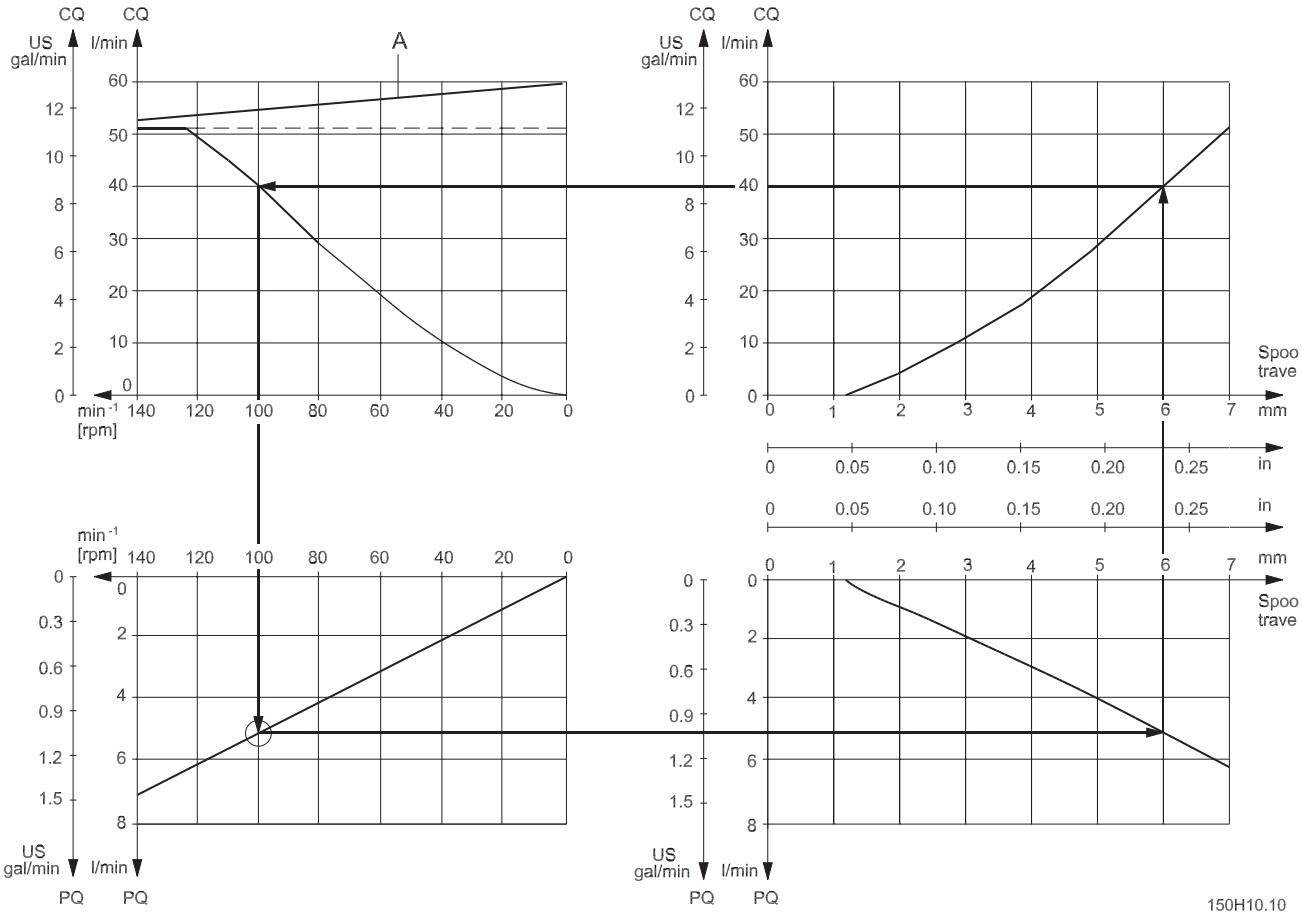
If you want to have sufficient supply at higher steering wheel speed (higher than 100 rpm) you must choose enough pump capacity for such a case.
On page 25 is shown flow characteristics for the different directional spools. The "40 l/min [10,57 US gal/min]" spool gives maximum cylinder flow 50 l/min [13.21 US gal/min] at end stroke.
If you in the example above calculate with maximum steering wheel speed 150 rpm, the minimum pump flow capacity must be:

Qpm = CQmax + PQmax = 50 + 7.5 = 58 l/min [15.32 US gal/min]

(Qmax comes from 50 cc/rev* 150 rpm = 7.5 l/min [1.98 US gal/min])

Technical Characteristics

Directional spool
Oil flow characteristic for spool 40/5



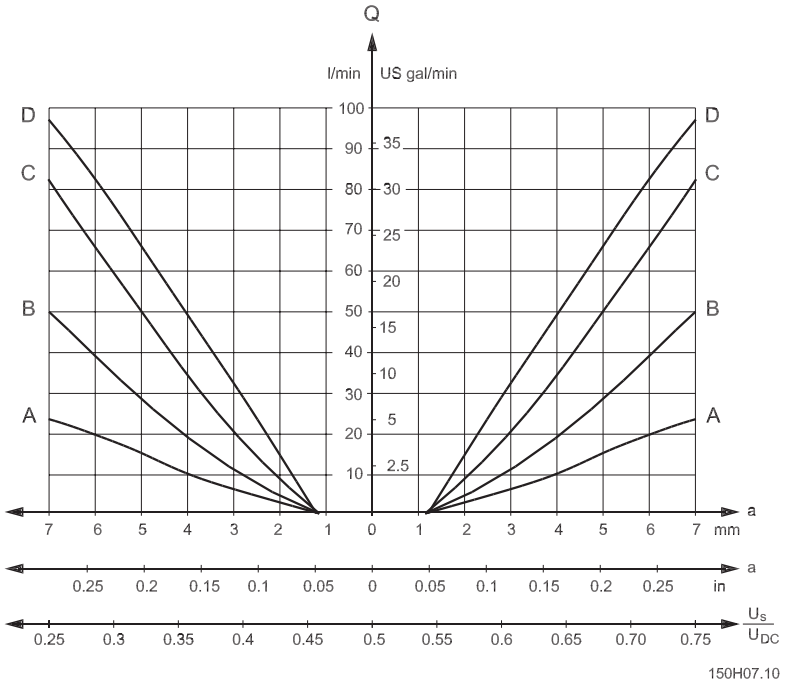
A: Flow available for steering, CQa = QP-PQ
QP = Pump flow
PQ = Pilot flow

The lower left diagram shows pilot flow as function of steering wheel speed. The values are valid for OSPCX 50 CN steering unit: 100 rpm steering wheel speed corresponds to 5 l/min. [1.3 US gal/min] pilot flow.
The lower right diagram shows spool travel as function of pilot flow:
5 l/min. [1.3 US gal/min] pilot flow gives 6 mm spool travel.
The upper right diagram shows cylinder flow as function of spool travel: 6 mm spool travel gives 40 l/min [10.6 US gal/min] cylinder flow.
The upper left diagram shows cylinder flow as function of steering wheel speed: 100 rpm steering wheel speed gives 40 l/min [10.6 US gal/min] cylinder flow.
Line A shows flow limit available for cylinder flow, when pump flow is 60 l/min. [15.9 US gal/min]. At 100 rpm 5 l/min. [1.3 US gal/min] is used for pilot flow.

Please contact the Sauer-Danfoss Organization regarding characteristics for other directional spools.

Technical Characteristics (Continued)

Directional spool
Cylinder flow characteristic for all directional spools



A = valid for spools for nominal cylinder flow CQ = 20 l/min [5.3 US gal/min]
B = valid for spools for nominal cylinder flow CQ = 40 l/min [10.6 US gal/min]
C = valid for spools for nominal cylinder flow CQ = 60 l/min [15.9 US gal/min]
D = valid for spools for nominal cylinder flow CQ = 80 l/min [21.1 US gal/min]

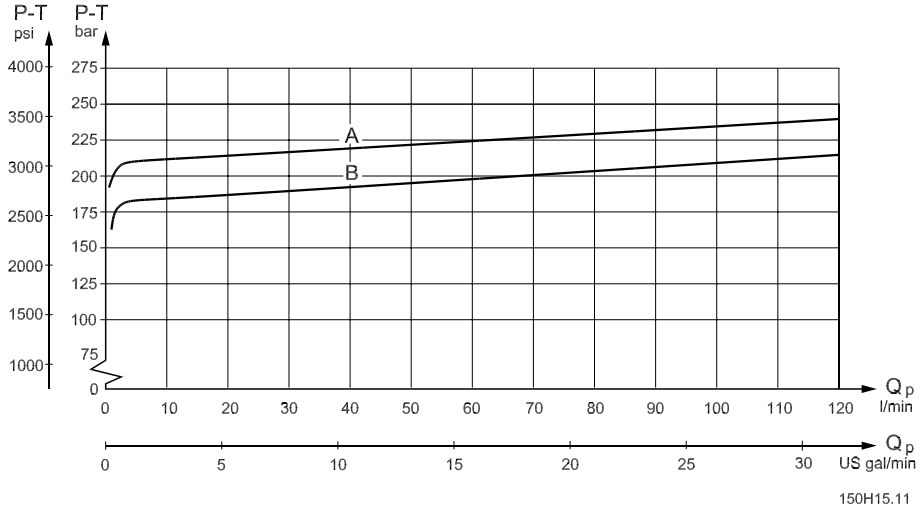
Technical Characteristics (Continued)

Pilot pressure relief valve: (P - T, Qp) characteristic

The pilot pressure relief valve protects the steering system against excessive pressure. The pilot pressure relief valve works together with the priority valve in the EHPS to limit the maximum steering pressure P-T. The pilot pressure relief valve is set at an oil flow to the priority valve of 40 l/min [10.6 US gal/min].
Setting tolerance: rated value +5 bar [72.5 psi]

A: 220 bar +5 / -0 bar
[3190 + 72.5 / -0 psi]

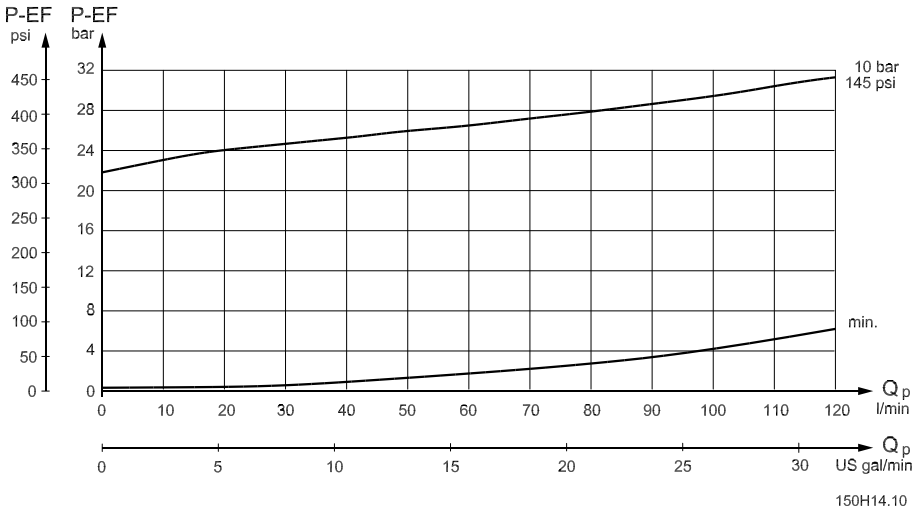
B: 190 bar +5 / -0 bar
[2756 + 72.5 / -0 psi]



Pressure drop P-EF for Sauer-Danfoss EHPS valve

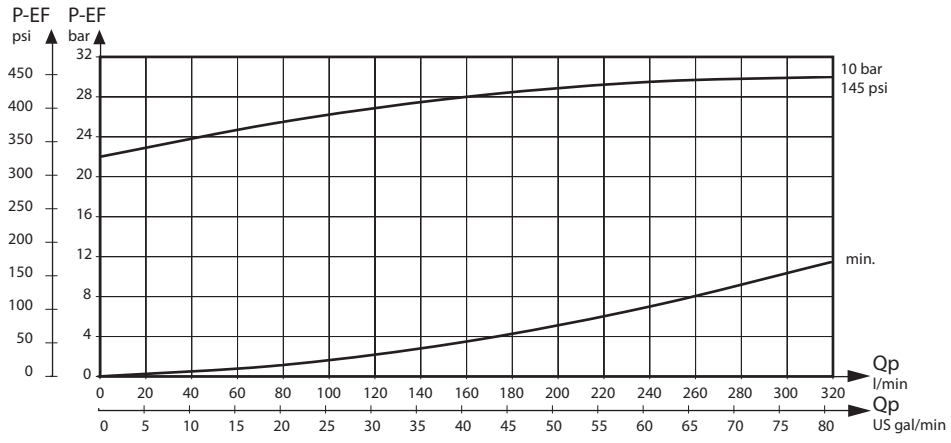
This data comes from measurements on a representative sample of EHPS valves from production. Oil with viscosity of 21 mm²/s [102 SUS] at 50 °C [122 °F] was used during measuring. Measurement made when pressure on the LS connection is zero. The minimum curve applies when the pressure on the EF connection is higher than the actual control spring pressure. The curve for control spring pressure of 10 bar [145 psi] applies when pressure on the EF port is zero.

Pressure Drop P-EF for OLS integrated in EHPS



150H14.10

Pressure Drop P-EF for OLS 320 Static Priority Valve flanged on EHPS



P301 019

Dimensions

G-port version (G, DIN 3852-2):
P, EF: G 3/4, 16 mm [0.63 in] deep
Ps, Ts, T, CL, CR, L, R: G 1/2,
14 mm [0.55 in] deep
LS: G 1/4, 12 mm [0.48 in] deep

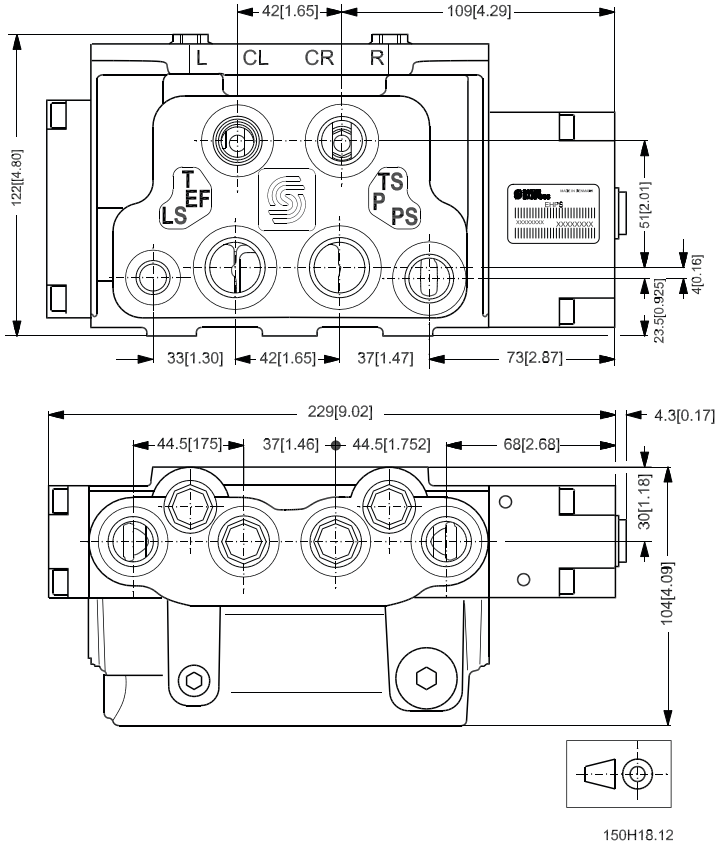
Metric-port version (ISO 6149-1):
P, EF: M27 • 2, 19 mm [0.75 in] deep
Ps, Ts, T, CL, CR, L, R:
M18 • 1.5, 14.5 mm [0.57 in] deep
LS: M12 • 1.5, 11.5 mm [0.45 in] deep

UNF-port version (ISO 11926-1):
P, EF: 1 1/16-12 UN, 19 mm [0.75 in] deep
Ps, Ts, T, CL, CR, L, R:
3/4-16 UNF 14 mm [0.55 in] deep
LS: 7/16-20 UNF, 11.5 mm [0.45 in] deep

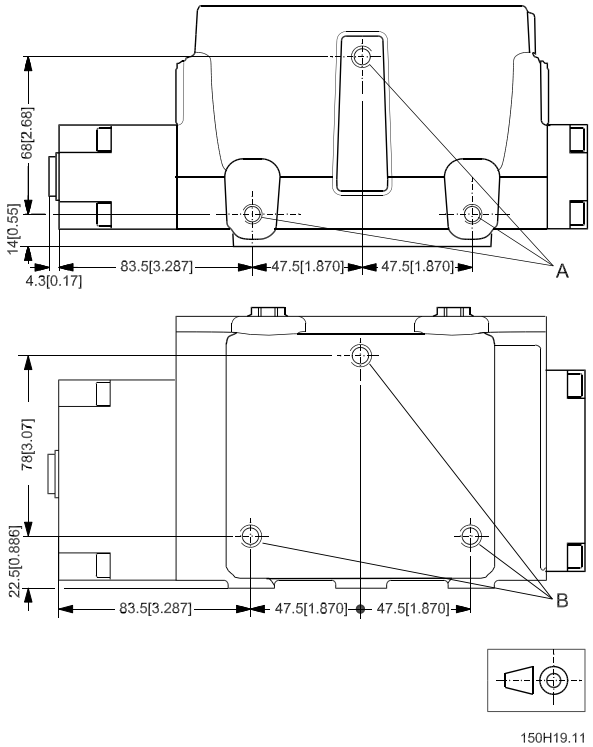
All versions:
A: M8 • 1.25, 10 mm [0.39 in] deep
B: M8 • 1.25, 10 mm [0.39 in] deep

The mounting surface for the EHPS must be plane. No spots exceeding the height of the area round the three M8 bolt holes allowed.

EHPS Type 0, stand alone



150H18.12



150H19.11

Dimensions

EHPS Type 1 and 2, stand alone

G-port version (G, DIN 3852-2):
P, EF: G 3/4, 16 mm [0.63 in] deep
Ps, Ts, T, CL, CR, L, R: G 1/2,
14 mm [0.55 in] deep
LS: G 1/4, 12 mm [0.48 in] deep

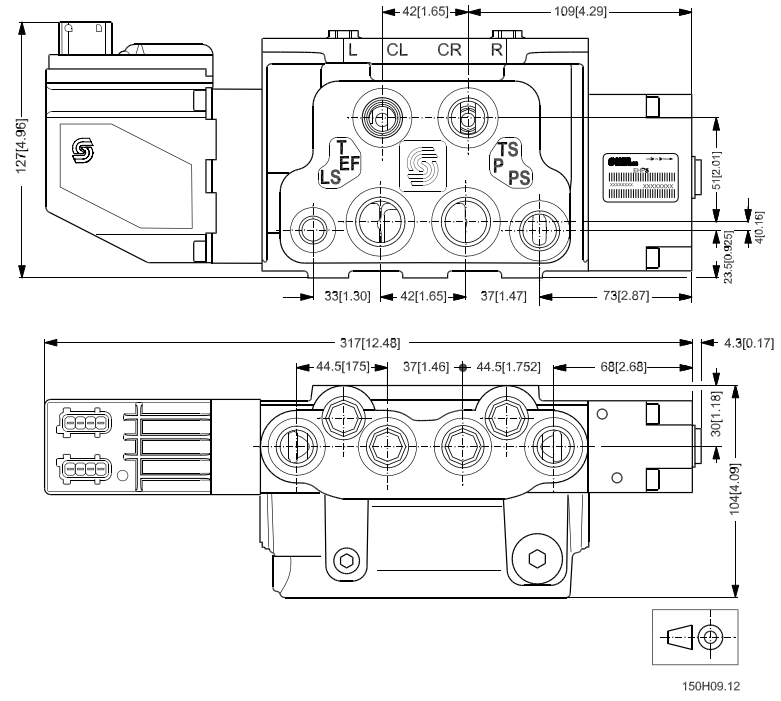
Metric-port version (ISO 6149-1):
P, EF: M27 • 2, 19 mm [0.75 in] deep
Ps, Ts, T, CL, CR, L, R:
M18 • 1.5, 14.5 mm [0.57 in] deep
LS: M12 • 1.5, 11.5 mm [0.45 in] deep

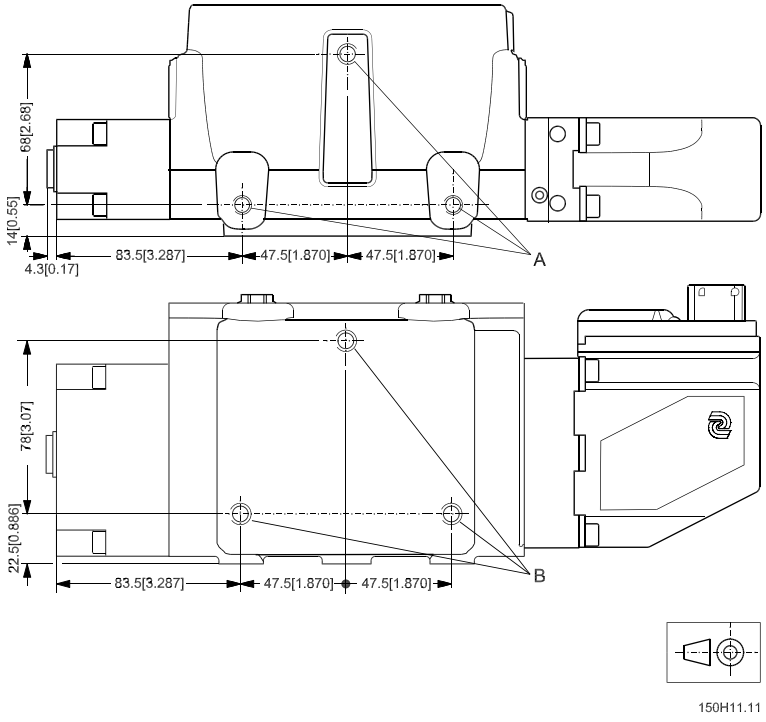
UNF-port version (ISO 11926-1):
P, EF: 1 1/16-12 UN, 19 mm [0.75 in] deep
Ps, Ts, T, CL, CR, L, R:
3/4-16 UNF 14 mm [0.55 in] deep
LS: 7/16-20 UNF, 11.5 mm [0.45 in] deep

All versions:
A: M8 • 1.25, 10 mm [0.39 in] deep
B: M8 • 1.25, 10 mm [0.39 in] deep

Type 1 has only one connector on PVE

The mounting surface for the EHPS must be plane. No spots exceeding the height of the area round the three M8 bolt holes allowed.





Dimensions

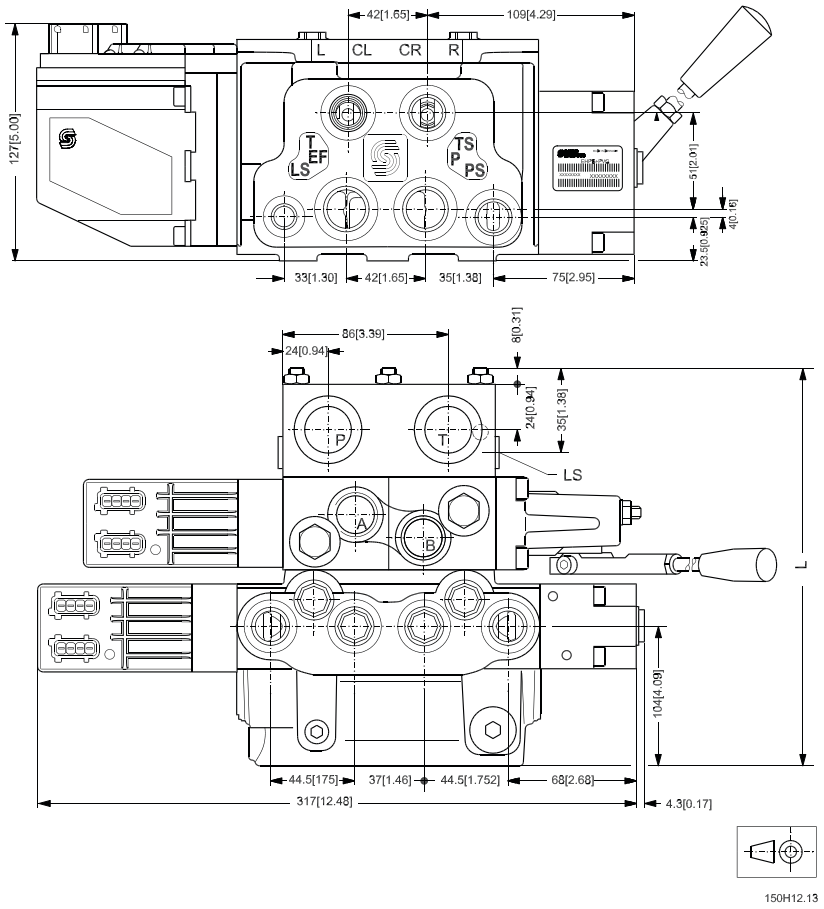
G-port version (G, DIN 3852-2):
P, EF: G 3/4, 16 mm [0.63 in] deep
Ps, Ts, T, CL, CR, L, R: G 1/2, 14 mm [0.55 in] deep
LS: G 1/4, 12 mm [0.48 in] deep

Metric-port version (ISO 6149-1):
P, EF: M27 • 2, 19 mm [0.75 in] deep
Ps, Ts, T, CL, CR, L, R: M18 • 1.5, 14.5 mm [0.57 in] deep
LS: M12 • 1.5, 11.5 mm [0.45 in] deep

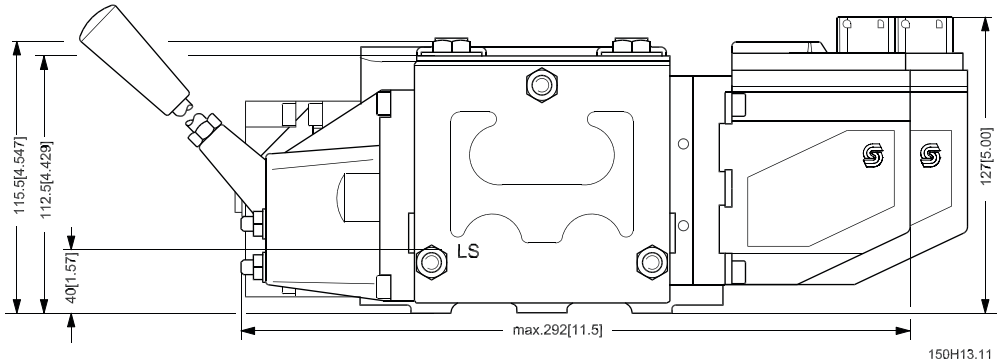
UNF-port version (ISO 11926-1):
P, EF: 1 1/16-12 UN, 19 mm [0.75 in] deep
Ps, Ts, T, CL, CR, L, R: 3/4-16 UNF 14 mm [0.55 in] deep
LS: 7/16-20 UNF, 11.5 mm [0.45 in] deep

All versions:
Bottom side fixing holes (A) in EHPS block, see page 29.
M8 x 1.25, 10 mm [0.39 in] deep

EHPS Type 1 and 2, with PVG



Type 1 has only one connector on PVE



PVB		1	2	3	4	5	6	7	8
L1	mm	208	256	304	352	400	448	496	544
	[in]	[8.19]	[10.08]	[12.00]	[13.86]	[15.75]	[17.64]	[19.53]	[21.42]

Dimensions

EHPS:
G-port version (G, DIN 3852-2):
P, EF: G ¾, 16 mm deep
Ps, Ts, T, CL, CR, L, R: G ½, 14 mm deep
LS: G ¼, 12 mm deep

Metric-port version (ISO 6149-1):
P, EF: M27 • 2, 19 mm deep
Ps, Ts, T, CL, CR, L, R: M18 • 1.5, 14.5 mm deep
LS: M12 • 1.5, 11.5 mm deep

UNF-port version: (ISO 11926-1):
P, EF: 1 1/16-12 UN, 19 mm deep
Ps, Ts, T, CL, CR, L, R: ¾ -16UNF 14 mm deep
LS: 7/16-20 UNF, 11.5 mm deep

OLS 320:
SAE-port version:
P, EF: 1 in SAE flange/M10 threads
LS: G ¼, 12 mm deep
or
LS: M12 • 1.5, 11.5 mm deep
or
LS: 7/16- 20 UNF, 11.5 mm deep

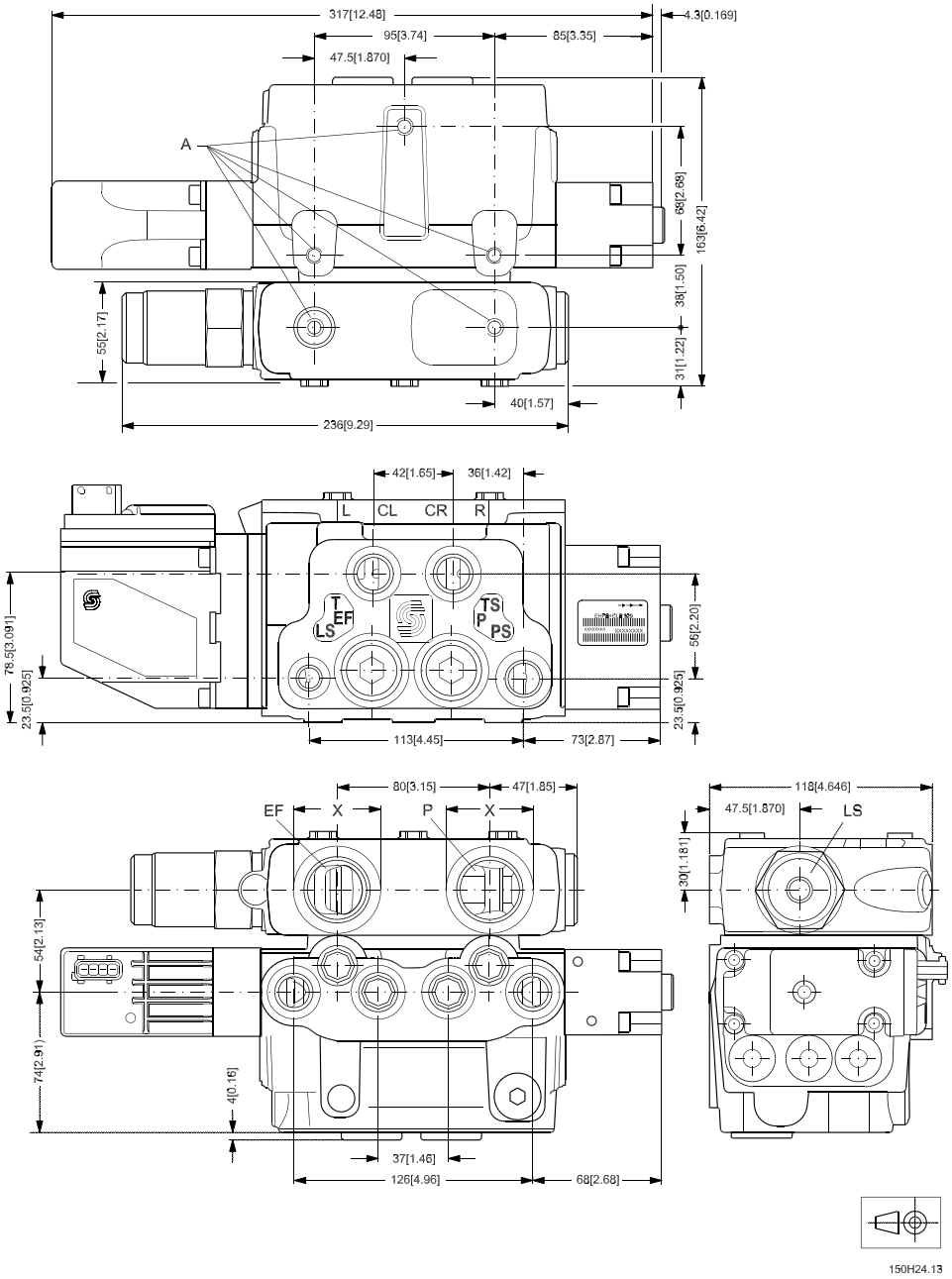
Metric-port version (ISO 6149-1):
P, EF: M33 • 2
x = ø43 mm (in)
LS: M12 • 1.5, 11.5 mm deep

UNF-port version: (ISO 11926-1):
P, EF: 1 5/16-12 UN
x = ø49mm (in)
LS: 7/16-20 UNF, 11.5 mm deep

All versions:
A: Bottom side fixing holes: M8 x 1.25, 10 mm deep, see page 29.

Type 2 has two connectors on PVE

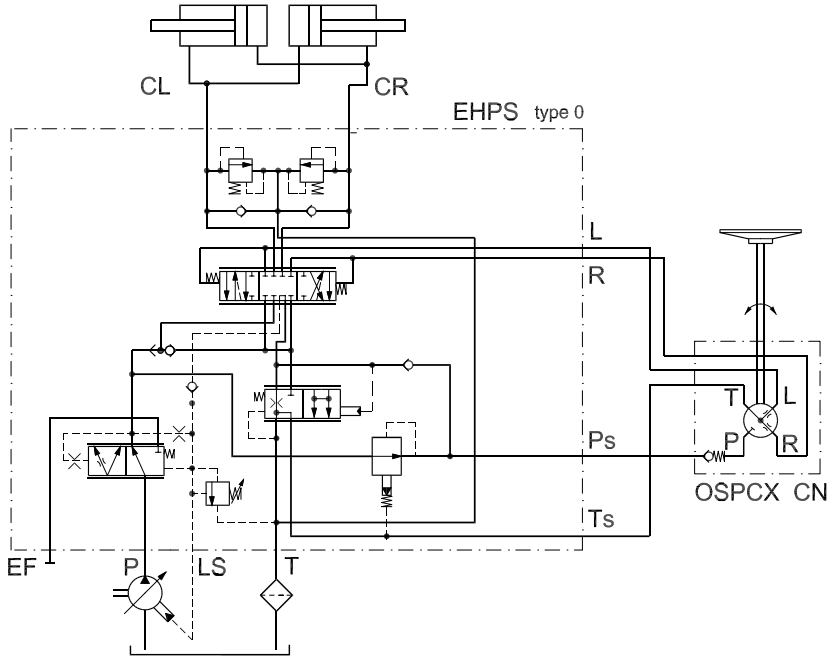
EHPS Type 1 and 2 with OLS 320



150H24.13

Hydraulic Systems

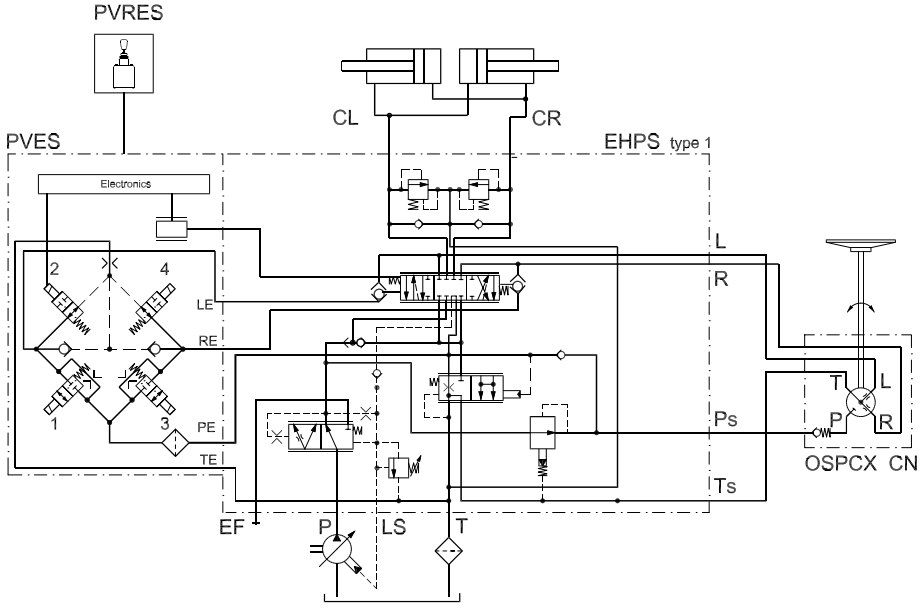
EHPS type 0, stand alone and OSPCX CN steering unit



150H06.11

EHPS type 1, stand alone, OSPCX CN steering unit and PVRES joystick

The vehicle can be steered with either the PVRES joystick or the OSPCX CN steering unit. The signal from the steering unit has priority on simultaneous activation of steering wheel and joystick.

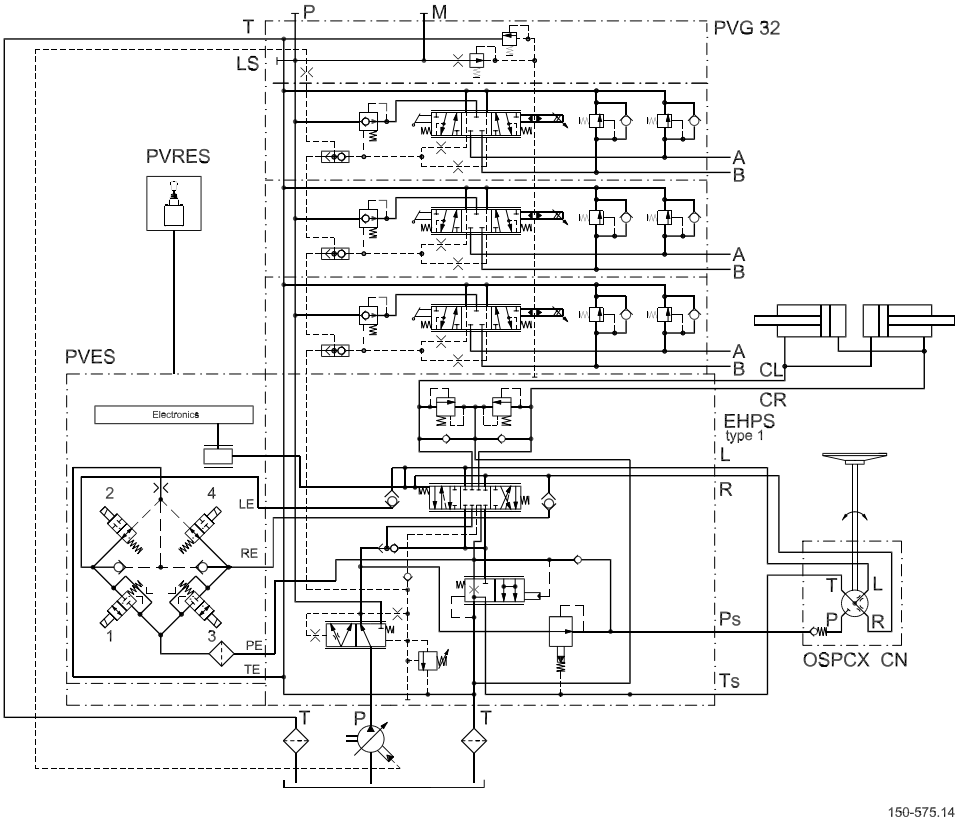


150H05.11

Hydraulic Systems

EHPS type 1 with PVG 32, OSPCX CN pilot steering unit and PVRES joystick

The vehicle can be steered with either the PVRES joystick or the OSPCX CN steering unit. The signal from the steering unit has priority on simultaneous activation of steering wheel and joystick.



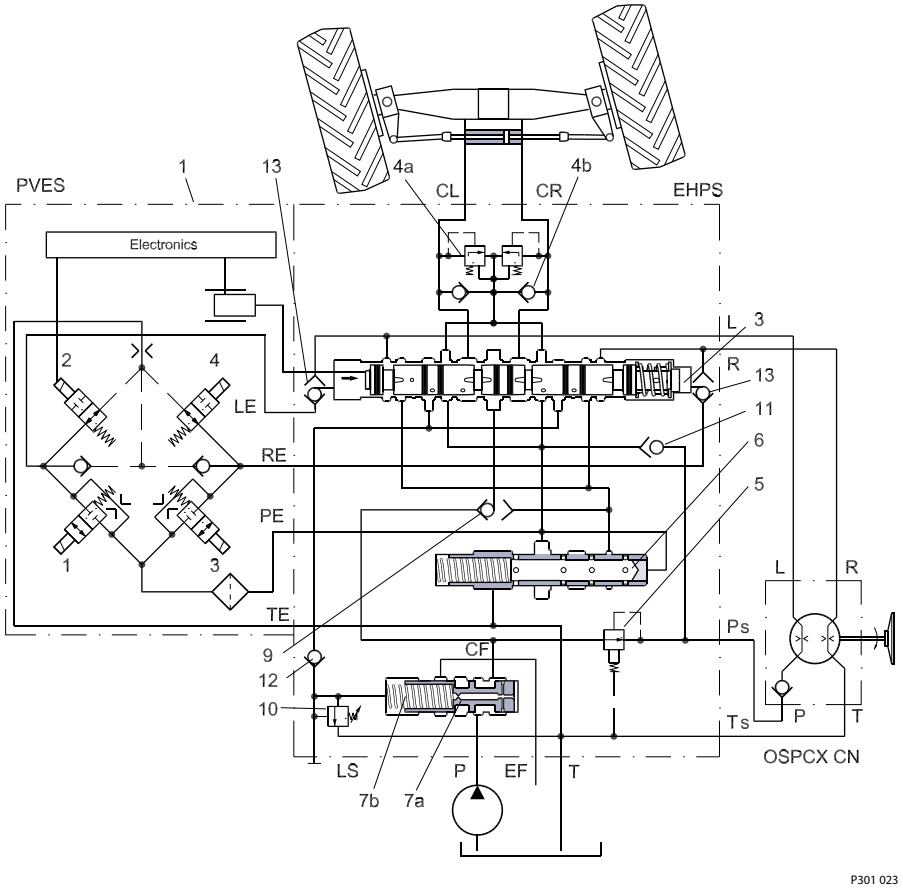
The joystick must be equipped with a neutral position contact to ensure that the PVES is not under tension in neutral position. PVRES joystick has a neutral position contact.
See Technical information for joysticks 520L0554

Steering Valve EHPS and Electrical Actuation PVE for EHPS

System Safety

1. Electrical actuation module
3. Directional spool
4a. Shock valves
4b. Suction valves
5. Pilot pressure reduction valve for steering unit
6. Metering valve
7a. Priority valve spool
7b. Priority valve spring
9. Emergency steering valve
10. Pilot pressure relief valve
11. Check valve for emergency steering
12 Check valve in LS line
13. Shuttle valves

Emergency Steering



When the pump oil supply fails*, the steering unit can be used as a hand pump depending on the weight of vehicle.
When steering the steering unit still gets oil from Ps on EHPS. When steering left the oil from the steering unit passes on to the L-port of the EHPS and it will fill the left side chamber of the directional spool (3), and so the spool moves to the right.

As there is no pump supply, there is no pressure in CF consequently there is no pressure on the left side of the emergency steering valve (9). Pilot oil from the steering unit is pushing on the right side of emergency steering valve, and causing it to move towards the left. Now pilot flow is led to the directional spool (3) and into the CL port and the cylinder moves. Return oil from the cylinder enters CR, and will pass over the directional spool (3) and the check valve (11) and it feeds the steering unit.
In this way the cylinder is directly moved by the oil flow from the steering unit, and the ratio is increased in comparison to normal steering situation with active pump supply.

When turning right, the movement of the directional spool (3) will be opposite. All other functions are equal as when steering left.

* Herby is meant when pressure in P-line to EHPS has dropped to less than 12 bar [174 psi]!! When pump pressure is larger than 12 bar [174 psi], emergency steering will not be possible due to metering valve (6) will stay open during steering.

System Safety (continued)

EHPS type 1 and type 2, prioritizing input signal

In case of active electrical steering (EHPS type 1 and type 2), the steering signal from pilot steering unit has highest priority:

- The oil supply to the steering unit is reduced to 30 bar [435 psi], controlled by pressure reduction valve (5)
- The oil supply to the PVES actuation module is adjusted to 12 bar [174 psi] by the metering valve (6)

If a driver coincidence activates a joystick steering left, and he grabs the steering wheel to steer counter (steer to the right), the signal from the steering wheel has priority as the pilot steering unit can generate 30 bar [435 psi] on the right side of the directional spool and the PVES can only generate 12 bar [174 psi] on the left side of the directional spool.

The joystick must be equipped wit a neutral contact to ensure that the PVES is not under tension in neutral position. Without a neutral position contact the joystick will release an electrical signal of $0.5 \cdot U_{DC.}$
If the EHPS is hydraulically activated the main spool is moved, thus changing the LVDT signal. There will be a difference between feedback and input signal and when this reaches more than 15% the PVEA will go into failure mode.

Note concerning type 1 and type 2 systems.
Such systems can be set up without any OSPCX steering unit in case the customer wants pure Steer By Wire (SBW) steering.
In such case it is important to connect L and R of EHPS to tank.
These tank connections are needed to ensure that directional spool of EHPS moves properly into neutral after ending steering input signal to PVE!

System Safety (continued)

Fault monitoring A fault monitoring system is provided in all PVES and PVED-CL modules. The system is available as passive fault monitoring type, which provides a warning signal only.

- Passive fault monitoring systems are triggered by three main events:

1. Input signal monitoring

The PVES input signal voltage is continuously monitored. The permissible range is between 15% and 85% of the supply voltage. Outside this range the section will switch into an active error state.

2. Transducer supervision

If one of the wires to the LVDT sensor is broken or short-circuited, the section will switch into an active error state.

3. Supervision of the closed loop

The actual position must always correspond to the demanded position (input signal). If the actual spool position is further than the demanded spool position (>12%,), the system detects an error and will switch into an active error state. On the other hand, a situation where the actual position is closer to neutral than that demanded will not cause an error state. This situation is considered "in control".
When an active error state occurs, the fault monitoring logic will be triggered:

Passive fault monitoring

- A delay of 250 ms before anything happens.
- The solenoid valve bridge will not be disabled but still control the main spool position.
- An alarm signal is sent out through the appropriate pin connection, no. 3.
- This state is not memorized. When the erroneous state disappears, the alarm signal will turn to passive again. However, the signal will always be active for a minimum of 100 ms when triggered.

To prevent the electronics from going into an undefined state, a general supervision of the power supply and the internal clock frequency is made. This function applies to PVES and PVED-CL and will not activate fault monitoring:

1. High supply voltage
   The solenoid valves are disabled when the supply voltage exceeds 36 V, and the main spool will return/stay in neutral.
2. Low supply voltage:
   The solenoid valves are disabled when the supply voltage falls below 8.5 V, and the main spool will return/stay in neutral.

System Safety (continued)

3. Internal clock

The solenoid valves are disabled when the internal clock frequency fails, and the main spool will return/stay in neutral.

On-road Operation

⚠ WARNING

The PVES or PVED-CL shall be de-energized while driving on-road. It is the OEMs responsibility to establish the necessary means to inform and de-energize the PVE from the cabin when driving on public roads.

Safety Considerations

⚠ WARNING

The Sauer-Danfoss range of PVE actuators are single string designs with limited on board fault monitoring. Sauer-Danfoss strongly recommends application of vehicle specific safety monitoring systems that will detect non-conforming steering and effectively disable electro-hydraulic actuators or issue appropriate warnings as the case may be. A minimum safety system should include a manual power switch to electrical power off electro-hydraulic actuators while driving on public roads.

For details, see:
- Technical information, PVE Series 4
- User Manual PVED-CL controller for Electro-Hydraulics Steering
or contact Sauer-Danfoss Technical Support Team

Order Specification

Order specification for EHPS and PVES

Specification table for Sauer-Danfoss EHPS steering valve. Fill in your company data and place x's in the table where appropriate and then send to your Sauer-Danfoss Sales Organization. For further explanation of specification: see page 22

Your company	**Name**	**Vehicle**	**Potential pcs/year**	**Completed by**	**Date**

Actuation module	Type 0 (none)						Type 1 (PVES)					Type 2* (PVED-CL)			
							Connector					Connector			
							AMP (A)					AMP (A)			
Directional spool	20/5		40/5		40/8		60/8		60/10			80/8		80/10	
Housing, basic	Stand alone (SA)						For PVG (PVG)					For OLS 320(OLS)			
Housing EHPS, threads	G						Metric (M)					UNF			
Housing OLS 320, threads (if any OLS 320)	SAE						Metric (M)					UNF			
Relief valves setting bar	100	110	120	130	140	150	160	170	180	190	200	210	220	240	250
Shock valves setting bar	160	175	190		210		230		240	250	265	280		300	320
Unit painted black	Yes (PB)										No				

*Type 2: Contact Sauer-Danfoss Sales Organization for software version and vehicle specific parameters to be downloaded in PVED-CL

Steering Valve EHPS and Electrical Actuation PVES for EHPS

Alternatively specify your EHPS by the following destinations as in the example below:

EHPS	Type 1A	80/8	OLS	M	M	240	320	PB

Actuation module
Directional spool
Housing, basic
Housing EHPS, threads
Housing OLS 320 (if any OLS), threads
Relief valve setting, EHPS
Shock valves setting
Unit painted black

Please fill in specification for your EHPS:

EHPS							

Only values stated in the table above are available for the EHPS specification.
When choosing housing for PVG, please fill in order specification for the PVG group.
In this PVG group the EHPS will replace the end cover for PVG.

Remember also to specify and order the OSPCX CN steering unit, see page 40 and 41.

Steering Unit OSPCX CN

Version

Closed center

Closed center steering units are blocked on their P port in the neutral position.

OSPCX CN: Steering units for steering valve EHPS.

OSPCX CN is a closed center steering unit with the L and the R connections open to the tank when in neutral position. OSPCX CN can only be used with Sauer-Danfoss steering valve EHPS.

OSPCX CN steering unit must not be connected directly to the steering cylinder.

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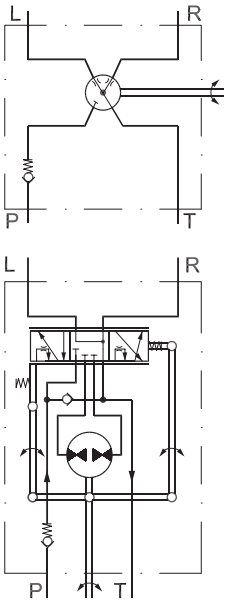

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OSPBCX CN
Closed center Non-reaction

Code Numbers and Weights

OSPCX CLOSED CENTER NON-REACTION STEERING UNITS

OSPCX CN in the table below have all the following valve function incorporated:

- Check valve in P-port

OSPCX CN in the table below have all soft neutral setting springs, see page 42

Steering unit	Code numbers			Weight kg [lb]
	Connections			
	European versions		Us Versions	
	G 1/2 S**	M18 • 1.5 - O* + S**	3/4 - 16 UNF O*	
OSPCX 50 CN			11031535	5.2 [11.5]
OSPCX 70 CN	150G4110	-	-	5.3 [11.7]
OSPCX 80 CN	-	-	150G4112	5.3 [11.7]
OSPCX 100 CN	150G4107	150G4108	150G4109	5.4 [11.9]

S** : countersinking around port connections (can not be used in connection with OVR angular block)
O* : O-ring chamfer on port connections

If you wish other specifications for your OSPCX CN steering unit, please fill in the order form on page 39 and contact the Sauer-Danfoss sales organization.

Steering Unit OSPCX CN

Specification Table for Non Catalogue Numbers of Sauer-Danfoss OSPCX CN Steering Units

Specification table for Sauer-Danfoss closed center steering units type OSPCX CN which are not available in the code number table.

Fill in with company data and x's in the table and send to your Sauer-Danfoss Sales Organization

Your company	**Name**	**Vehicle**	**Potential, pcs/year**	**Completed**	**Date**
Steering unit type	OSPCX CN				
Displacement cm3/rev OSPCX CN	50	60	70	80	100
Port threads	G 1/2 S**	M 18 • 1.5 O* + S**	$^{3}/_{4}$-16UNF O*		
Neutral setting springs	Soft: 0.15 - 1.8 Nm [1.33 - 15.9 lbf•in] in normal steering situation	Standard: 0.8 - 3 Nm [7.10 - 26.55 lbf•in] in normal steering situation	Strong: 1.5 - 4 Nm [13.27 - 35.40 lbf•in] in normal steering situation		
Unit painted black	Yes	No			

S** : Spot face around port connections (can not be used in connection with OVR angular block)
O* : O-ring chamfer on port connections

Steering Unit OSPCX CN

Technical Data

Common data

Look in sub catalogue: "General, steering components"

Manual steering pressure

Look in sub catalogue: "General, steering components"

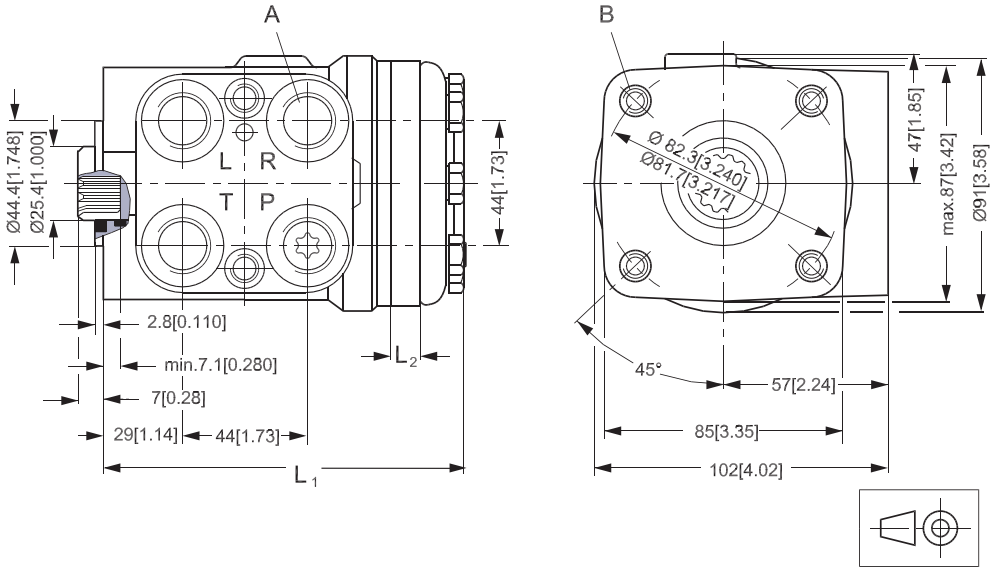
Displacement, flow and pressure

Steering unit	Displacement cm3 /rev [in3 / rev]	Ratet oil flow l/min [US gal/min]	Max. pressure on connections		
			P bar [psi]	T bar [psi]	L, R bar [psi]
OSPCX 50 CN	50 [3.05]	5 [1.32]	125 [1813]	25 [363]	100 [1450]
OSPCX 60 CN	60 [3.70]	6 [1.58]			
OSPCX 70 CN	70 [4.30]	7 [1.85]			
OSPCX 80 CN	80 [4.90]	8 [2.11]			
OSPCX 100 CN	100 [6.10]	10 [2.64]			

Dimensions OSPCX CN

European version:
A: G ½ w. spot face or M18 • 1.5 ISO 6149
15 mm (0.59 in) deep
B: M10 • 1.5,
16 mm (0.63 in) deep

US version:
A: ¾ - 16 UNF O-ring boss;
15 mm (0.59 in) deep
B: 3/8 - 16 UNC, 16 mm (0.63 in) deep



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Steering unit	L1 mm [in]	L2 mm [in]
OSPCX 50 CN	126 [4.96]	6.5 [0.26]
OSPCX 60 CN	128 [5.04]	9.1 [0.36]
OSPCX 70 CN	128 [5.04]	9.1 [0.36]
OSPCX 80 CN	129 [5.08]	10.4 [0.41]
OSPCX 100 CN	132 [5.20]	13.0 [0.51]

Notes

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520L0521 • Rev CA • Oct 2009

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